2008

the role of an audio-visual attentional stimulus in influencing affective responses during graded cycling exercise

Erik Lind
Iowa State University

The role of an audio-visual attentional stimulus in influencing affective responses during graded cycling exercise

by

Erik Lind

A dissertation submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Major: Kinesiology (Behavioral Basis of Physical Activity)

Program of Study Committee:
Panteleimon Ekkekakis, Major Professor
Rick L. Sharp
Greg Welk
Mack C. Shelley
Doug A. Gentile

Iowa State University

Ames, Iowa

2008

TABLE OF CONTENTS

LIST OF FIGURES

volitional exhaustion. Significant time main effect ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

Figure 9. Bar graph of perceived exercise enjoyment across experimental conditions of Sensory Deprivation (no visual or auditory feedback), Biofeedback (heart rate and respiration), and Music-Television. Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

LIST OF TABLES

ABSTRACT

The purpose of this study was to: (a) identify a range of exercise intensity in which an attentional focus strategy is and is no longer effective as a cognitive manipulation and (b) investigate the effect of an attentional dissociative and attentional associative cognitive strategy on affective responses during graded cycle ergometer exercise. Thirty-four participants (17 men, 17 women), who met the criteria for involvement, underwent an initial familiarization trial and three subsequent experimental trials on separate days, approximately one week apart. During the familiarization trial, participants were given an explanation of the procedures of the study, completed required paperwork, and were familiarized with the laboratory environment, equipment, and psychometric measures. The experimental trials were counterbalanced, involved the same graded cycling exercise to volitional exhaustion protocol, and only differed in the attentional manipulation employed. An *attentional association condition* consisted of auditory amplification of participants' breathing, through headphones, and graphically displaying heart rate data on a 42-inch monitor placed at eye level approximately 2 m in front of the cycle ergometer. An *attentional dissociation condition* consisted of participants watching and listening to a self-selected music digital video disc (DVD) through headphones and on the 42-inch monitor. In the *sensory deprivation condition*, participants wore both earplugs and sound-attenuating headphones and the 42-inch monitor remained blank. Affective valence, the main dependent variable, was measured using the Feeling Scale (FS; Hardy & Rejeski, 1989). The manipulation checks of perceived exertion and attentional focus were measured using the Rating of Perceived Exertion scale (RPE; Borg, 1998) and an attentional focus scale (AFS; Baden et al., 2004), respectively. Affective, exertional, and attentional focus responses were sampled at appropriate time points pre-, during, and post-exercise. The results of the study indicated similar physiological strain across experimental conditions as evident by non-significant differences in heart rate, oxygen consumption, and power output values. Moreover, the attentional focus manipulation

was successful as participants in the Music-Television (MTV) and Biofeedback (BF) conditions reported significantly higher attentional dissociative and lower attentional associative scores, respectively, compared to a sensory deprivation (SD) condition. The manipulation is also partially confirmed by lower ratings of perceived exertion (RPE) in the MTV condition compared to both the BF and SD conditions. Participants reported more positive affective responses throughout the MTV condition compared to the BF and SD conditions, and affective responses stabilized around the ventilatory threshold in the MTV condition whereas there was a continued decline in the SD and BF conditions. Following exercise, participants rated the MTV condition as producing greater post-exercise perceived enjoyment compared to the BF and SD conditions. The results provide support for the Dual Mode Model as exercising to volitional exhaustion during attentional dissociation resulted in a plateau of affective responses around the ventilatory threshold while conditions of sensory deprivation and attentional association showed consistent patterns of less positive/more negative affective responses.

CHAPTER 1. OVERVIEW

1.1 Introduction

There remains a strong research interest in the relationship between attentional association (e.g., awareness of the bodily responses with respect to some form of stimuli) and attentional dissociation (e.g., focusing attention on an external stimuli and away from bodily sensations) and exercise. The extant literature on both the broader research area of attentional association and attentional dissociation and specific investigations of these strategies (e.g., music, watching television) have been characterized by a lack of an adequate theoretical paradigm. Studies within the area of attentional association and attentional dissociation have generally examined the effectiveness of manipulating focal awareness inwardly or externally on various outcome variables related to the exercise experience. Similarly, research on music and other audio-visual stimuli has also investigated the presumed dissociative effects of these interventions on various outcome variables. These variables of interest have generally included measures of affective ratings of pleasure-displeasure, exertional responses (e.g., perceived exertion), exercise economy (e.g., heart rate responses, differences in oxygen consumption), and exercise tolerance (e.g., time to exhaustion, work output). A critical review of the extant literature (Lind, Welch, & Ekkekakis, in press) highlights the inconsistent findings, suggesting that little is known about the true effectiveness of attentional associative or attentional dissociative strategies to attenuate physiological strain and/or enhance the exercise experience by improving affective ratings. These inconclusive results are compounded further by the fact that previous research is characterized by considerable reliance on selected participant characteristics, arbitrarily chosen exercise workloads, and other methodological and experimental design issues.

In response to these inconsistent results, researchers within both the broader attentional focus realm and specific music and other audio-visual stimuli area have called for future investigations based on conceptually sound theories (Karageorghis & Terry, 1997; Masters & Ogles, 1998; Rejeski, 1985). Past attempts at explaining the effectiveness of attentional focus strategies consist of the "*competition of cues*" explanation advanced by Pennebaker and Lightner (1980) and the parallel processing of information model posited by Leventhal and Everhart (1979) and later reconceptualized by Rejeski (1985) to apply to physical activity. In each case, the assumption is that a number of cues, both internal and external, exists to which one can attend. Focus on one set of cues (e.g., an external perceptually salient stimulus) will draw attention away from a different set of cues (e.g., internal sensations associated with the homeostatic perturbations induced by exercise). In some cases, there are environmental or social-cognitive factors that act on the perception of physiological cues (Rejeski, 1985). For example, the degree of self-efficacy an individual has for exercise or the non-verbal cues of others (e.g., grimacing) during exercise may influence how he or she perceives physiological cues when exercise starts to become challenging.

While the contribution of these past explanations cannot be underscored enough, the problem of inconsistent findings still remains. Exercise intensity is an important component of the exercise experience that these past explanations do not sufficiently address. To that end, the Dual Model Model (DMM; Ekkekakis, 2003) is a psychobiological conceptual model that takes into consideration the role of exercise intensity on affective responses. Specifically, affective responses are theorized to be the result of the interplay between top-down cognitive processes (e.g., listening to music) and bottom-up interoceptive cues (e.g., disturbances to the internal *milieu*). The influence of either cognitive factors or interoceptive factors on the response of pleasure or displeasure is thought to shift systematically with increasing exercise intensity and reflect the saliency of each pathway to affective centers of the brain.

The purpose of this study was to examine affective responses under attentional associative, attentional dissociative, and control conditions across a range of exercise intensity levels using the Dual Mode Model as the underlying theoretical paradigm. In particular, the DMM hypothesizes that cognitive strategies will have little influence on ratings of pleasure-displeasure at low exercise intensities, demonstrate a stronger influence on affective responses approximate to the ventilatory threshold, and eventually become less effective at manipulating affective ratings as the individual nears his or her maximal aerobic capacity. In doing so, this study endeavored to expand the extant body of research pertaining to attentional focus strategies, specifically the use of a selected attentional associative technique (i.e. biofeedback) and of an attentional dissociative strategy (i.e. music and audio-visual stimuli), by utilizing a psychophysiological model expressly designed to predict the affective response pattern in relation to varying exercise intensity levels.

1.2 Statement of the Problem

What would the patterns of affective responses be under conditions of sensory deprivation (no visual or auditory feedback), attentional association (biofeedback of heart rate and ventilation), and attentional dissociation (music DVD) before, at the moment of, and after the ventilatory threshold during a bout of recumbent cycling exercise to volitional exhaustion? Furthermore, would any differences in affective responses during the exercise bout influence post-exercise ratings of affective valence and exercise enjoyment?

1.3 Research Hypotheses

Therefore, in accordance with the Dual Mode Model, it was predicted that:

(a) Affective ratings of pleasure-displeasure during a graded cycling ergometer exercise test would be positive at low and moderate intensity exercise levels, but initiate a trend towards more negative responses at intensities higher than the ventilatory threshold through the conclusion of the exercise test.

(b) An attentional associative condition would result in less positive/more negative affective responses starting approximate to the ventilatory threshold during a graded cycling ergometer exercise test compared to an attentional dissociative condition and sensory deprivation condition. Conversely, an attentional dissociative condition would delay the onset of less positive/more negative affective responses approximate to the ventilatory threshold compared to an attentional associative condition and a sensory deprivation condition.

(c) An attentional dissociative condition would result in more positive affective responses and enjoyment during a cool down and recovery period compared to an attentional associative condition and a sensory deprivation condition.

CHAPTER 2. REVIEW OF LITERATURE

2.1 Background

2.1.1 Causal Chain of Exercise Intensity, Affect, and Exercise Adherence

A proposed causal chain linking exercise intensity, affective responses of pleasure-displeasure, and exercise adherence has been proposed by Ekkekakis (Ekkekakis, 2005; Ekkekakis & Lind, 2006). The argument is based on research which demonstrates that increases in exercise intensity reliably result in a curvilinear trend of affective responses with relation to the ventilatory threshold (VT). The VT represents a physiological landmark of the transition from aerobic metabolism to anaerobic supplementation. In other words, below the VT, theoretically, the activity can be maintained for prolonged periods due to the maintenance of a physiological steady state. Conversely, above the VT, the time to fatigue and subjective need to stop the activity is driven by the inability to maintain a physiological steady state and the accumulation of various metabolic byproducts that signal the need to terminate the activity. With respect to affective ratings of pleasure-displeasure, at lower to moderate exercise intensities (i.e. below or approximate to the VT) affective responses are mostly positive. However, starting at intensities higher than the VT and continuing to maximal aerobic capacity, a curvilinear trend in affective responses is initiated towards less positive and eventually more negative responses. If the exercise bout is perceived as not enjoyable or displeasurable, due in part to high exercise intensity, then noncompliance is more likely to result.

Numerous cognitive strategies have been proposed to influence the dose-response relationship between exercise intensity and affective responses. Strategies such as attentional focus (internal focus or association, external focus or dissociation) and distraction (e.g., audio and visual stimuli) have been touted as methods to attenuate the physiological strain and/or enhance the affective response to exercise. The extent, however, to which each strategy is effective remains unclear.

2.1.2 Dual Mode Model: Reconciling the Quandary

There have been many previous attempts at explaining the contribution of attentional cues on individual responses during physical activity. Pennebaker and Lightner (1980) argued that external (i.e. environmental information) and internal (i.e. awareness of bodily responses) cues compete for limited focal awareness. Whether the individual responds more negatively or positively depends on whether internal or external cues, respectively, are being attended. Leventhal and Everhart (1979) described a model that posited separate, but parallel pathways for the processing of stimulus attributes and emotional reactions. While an individual always perceives information about a specific stimulus on a preconscious level, the stimulus' qualities only shift into focal awareness once filters or channels are opened. In other words, the extent to which attentional channels are open (as in the case of association) or closed (as in the case of dissociation or distraction) determines whether the stimulus qualities enter into focal awareness. Rejeski (1985) extended Leventhal and Everhart's (1979) model, which was originally developed to explain the response to painful stimuli, to account for feelings of fatigue and perceived exertion experienced during exercise.

The Dual Mode Model (Ekkekakis, 2003; Ekkekakis & Acevedo, 2006; Ekkekakis, Hall, & Petruzzello, 2005) provides a significant conceptual advancement over these past explanations. The DMM accounts for the influence of exercise intensity on affective responses. The model proposes that affective responses of pleasure or displeasure reflect the interplay of a pathway of top-down, cognitive processes, such as self-efficacy for exercise, contextual factors of the exercise setting, and cognitive strategies including attentional focus, and a pathway of bottom-up, interoceptive cues, such as the onset of symptoms related to increased physiological strain. Each pathway (hence, the *dual mode*) shares a common endpoint, namely the affective centers of the brain. While each pathway continues to be activated during a bout of exercise, it is the exercise intensity that determines which pathway dominates the affective center and generation of pleasure or displeasure.

Exercise intensity is organized along three general domains with respect to the relative contribution of aerobic metabolism or anaerobic supplementation within each domain. Specifically, the moderate domain of exercise intensity represents the level at which a physiological steady state via aerobic metabolism can be maintained for prolonged periods of time. Blood lactate and oxygen consumption values remain relatively stable and affective responses are accordingly positive with low to moderate influence of cognitive processes.

As exercise intensity increases, a shift into the heavy domain of exercise intensity takes place. Within this domain, there is an increased, yet manageable physiological strain. This domain marks the transition from aerobic metabolism to anaerobic supplementation and extends from the ventilatory threshold to the maximal lactate steady state (i.e. the highest level of work rate in which blood lactate is stabilized). While a physiological steady state can be re-established after several minutes of exercise at this intensity domain, there is an associated increase in physiological strain and affective responses tend to show greater inter-individual variability within this domain. This is due, in part, to the fact that interoceptive cues start to pose a challenge but the intensity of the cues is not overwhelming to the individual. Thus, cognitive processes that emerge to deal with the challenge have primacy in influencing affective responses within this domain.

The transition from the heavy into the severe domain of exercise intensity is characterized by an inability to maintain a physiological steady state. The range within this domain is narrower compared to either the moderate or heavy domains as there is a continuous rise in oxygen consumption and blood lactate concentration up through the point of volitional exhaustion. Cognitive strategies are hypothesized to be ineffective within this domain as interoceptive cues override such strategies and result in more negative or less positive affective responses.

2.2 Summary of Findings

2.2.1Audio-Visual Distracters and Human Movement

The study of the role of music in human movement has a long research history. Music has historically been associated with aesthetic, coordinated movements of both the athletic performer and exerciser (Höhne, 1979), suggesting a natural extension between musical rhythms and synchronized human movement (Brown, 1980; Hohler, 1989; Karageorghis, 1999). "*Listening to music*" and "*exercising*" are commonly employed mood-regulating strategies (Stevens & Lane, 2000; 2001), and it appears that individuals select music appropriate to the situation and according to whether the goal is to increase or decrease arousal (North & Hargreaves, 2000). Musical scores from movies such as *Rocky* or *Chariots of Fire* have been shown to evoke strong emotional descriptors such as *determination*, *desire to excel*, *gets me pumped up*, *motivation*, *fluid motion*, *persistence*, *achieving goals*, *heartbeat*, *sweating*, *confidence*, *inspirational*, and *invigorating* (Snyder, 1993). Findings from descriptive and experimental research highlight individual preference for playing music in health and fitness clubs and music's qualities to contribute or enhance the exercise experience (Bartholomew & Miller, 2002; Gfeller, 1988; Kendzierski & DeCarlo, 1991;

Priest, Karageorghis, & Sharp, 2004; Szabo & Griffiths, 2003). Collectively, the findings make it easy to understand the natural research interest in investigating the relationship between music and exercise performance and have prompted researchers to focus on the motivational qualities of music (Karageorghis, 1999; Karageorghis & Deeth, 2002; Karageorghis & Terry, 1997; Karageorghis, Terry, & Lane, 1999; Priest, Karageorghis, & Sharp, 2004).

More recently, researchers have begun to examine the role of visual distracters, either alone or in combination with auditory stimuli, on physiological and affective responses during exercise. This emerging area within exercise psychology research includes the use of virtual reality computer programs, monitors attached to exercise machines, and multiple television sets mounted on walls in fitness facilities. The underlying assumption is that these services or products, irrespective of any other influence, can and will improve the exercise experience, and disregards the influence of the intensity at which the individual exercises on whether pleasure or displeasure is experienced. Yet, the literature on attentional dissociative or distraction strategies across various affective, exertional, and physiological facets of physical activity is characterized by equivocal findings. Thus, "*mind over muscle*" strategies, such as listening to music and/or attending to audio-visual stimuli, need to be re-examined in order to identify the basis for the inconclusive results.

2.3 Review of Findings

Based on the proposed chain linking exercise intensity, affective responses, and adherence to exercise programs noted previously, the findings from this literature review are organized in the following manner. Studies that have examined the broader category of attentional association-dissociation (A/D) strategies are presented first followed by a summary of research pertaining to more specific audio-visual (A-V) stimuli. In accordance with the central role to this study, the relationship between A/D and A-V strategies and affective responses are presented. Second, the relationships between A/D and A-V strategies and perceived exertion and indices of exercise economy are presented to provide the reader additional insight as to the effectiveness of these strategies. Third, physiological responses related to exercise economy are considered in light of the A/D and A-V literature. Finally, the literature review concludes with a brief description of issues that have hindered a clearer understanding of the effectiveness of attentional focus strategies.

2.3.1 Attentional Association and Dissociation and Exercise: Affective Responses

Studies examining the effect of A/D strategies on psychological responses have focused on a wide range of variables, including affective responses, cognitive performance, and program adherence. Some researchers have proposed that exercise-induced affective responses represent a type of associative experience. For example, in a series of studies on marathon running and self-regulatory processes, Schomer (1986, 1987a, 1987b, 1990) argued that an internal/task-related associative strategy consisted, in part, of "feelings and affect" (p. 45; 1990). These thoughts were composed of general whole-body sensations, feelings of vitality or fatigue, and non-specific overall body tiredness and/or stiffness. Researchers have examined the range of psychological responses, from basic affect to specific emotional feeling states to broad mood states.

2.3.1.1 Affective, Emotional, and Mood-related Measures

Affective, emotional, and mood-related responses have received scarce attention within the A/D literature (29 out of 88 studies). Investigations of the basic affective dimension of pleasure-displeasure in A/D research have been based on the Feeling Scale, an

11-point rating scale ranging from “I feel very good” (during exercise) to “I feel very bad” (Hardy & Rejeski, 1989). Based on the results of studies using this measure, both association and dissociation have been found to be related to declines in pleasure. Researchers have observed declining pleasure ratings with a dissociative strategy during treadmill exercise at 90% VO_2max (Beaudoin, Crews, & Morgan, 1998), as well as greater post-exercise distress reports in untrained participants performing stair-climbing exercise (Brewer, Van Raalte, & Linder, 1996). Baden et al. (2004) observed a relation between more negatively valenced affective responses and greater associative thinking during 20 min of treadmill running at 75% peak treadmill running speed. Participants exercised under conditions in which they (a) were informed of how long they would be running ("20-min"), (b) were told they would run for 10 min and then unexpectedly were told to run for 10 additional min ("10-min"), or (c) were not informed of the duration ("UN"). In each 20-min condition, there was a significant linear increase in associative thinking over time. There was a significant decline in pleasure ratings between minutes 10 and 11 during the "10-min" condition compared to either the "20-min" or "UN" conditions. Other authors have also commented on the phenomenon of parallel increases in associative thought content and decreases in pleasure and enjoyment. For example, Brewer et al. (1996) noted that “*focusing on distress cues while performing an endurance task is counterproductive in terms of both performance and quality of experience (i.e., pain, affect)*” (p. 12).

At the other end of the attentional focus continuum, association and negatively valenced affective ratings have also been found to be related. Welch and colleagues (2007) noted declining pleasure ratings reported by young physically inactive women during a cycle ergometer test to volitional exhaustion. This decline in affective valence was paired with more associative thinking, particularly beyond the ventilatory threshold (VT). The authors noted that, "*on average, participants held a greater awareness of the physical sensations of the physiological changes around the VT and beyond, which is likely to manifest itself in both the type of attentional focus reported and the affect experienced*" (p. 416).

Besides A/D, other concurrent cognitive appraisals may also be influential. Cioffi (1991) had participants perform 10 min of cycle ergometry at 60% VO_2max either with or without instructions to closely monitor physical sensations. Half of the participants within each condition were then informed that they could be randomly shocked during the trial. Post-experimental examination of the physical sensations experienced revealed that, regardless of receiving or not receiving instructions to monitor physical sensations, individuals who had received the threat rated their physical sensations as more unpleasant compared to the no-threat group.

Other investigations of A/D strategies have focused on distinct feeling states. The most commonly used instrument to measure these specific states has been the Exercise-induced Feeling Inventory (EFI; Gauvin & Rejeski, 1993). It should be noted that, unlike the FS, the EFI has typically been administered before and after exercise, not during. Contrary to the previously discussed findings, dissociation has been consistently linked to improvements in the feeling states of *Revitalization*, *Positive Engagement*, and *Tranquility*, and reductions in *Physical Exhaustion* during submaximal aerobic exercise in young, healthy participants (Blanchard, Rodgers, & Gauvin, 2004; LaCaille, Masters, & Heath, 2004).

Studies examining other affective states have reported varying relationships with A/D strategies. For example, Durtschi and Weiss (1984) found that "non-elite" Olympic-trial marathon runners were more anxious in the days prior to and immediately before the event compared to their “elite” (invited) counterparts. Subsequent analyses of thought-content reports provided by the non-elite competitors showed greater dissociative thinking than elite competitors during the event. Using a similar sample but investigating a rather different phenomenon, Masters (1992) reported a significant positive correlation between dissociation and the euphoric “*runner’s high*” among marathon competitors. More recently, Couture et al. (1994) found that only the control group reported lower perceived fatigue scores during a military march, whereas the experimental groups of association (i.e., biofeedback), dissociation (i.e., meditation), and combined association-dissociation (i.e., biofeedback and meditation) did not.

Finally, some researchers have focused on broad mood states. With respect to ultraendurance events, association has been found to be related to worsening mood states (Sacks et al., 1981) and the variance in negative mood states can be almost entirely accounted for by pain sensations (Kirby, 1996). The effects of dissociation, on the other hand, appear less consistent. Reports of no effect (Fillingim, Roth, & Haley, 1989) or fewer physical symptoms and more positive mood with dissociative strategies (Fillingim & Fine, 1986) have been published, even from the same laboratory. However, exercise intensity was not precisely controlled in these studies.

Pennebaker and Skelton (1978) provided a helpful theoretical basis for understanding the link between psychological responses and A/D strategies. They argued that simply attending to physical symptoms intensifies the sensations and that these sensations are interpreted based on contextual cues. Mood states can serve as contextual cues. Results from their investigations highlight low to modest correlations between negative mood states and physical-symptom reporting. Given that physical symptoms are influenced by both attentional focus and interpretive cues, these investigators recommended that future research should examine "*which situational variables force attention to the body and bring in to play various* (interpretive) *sets*" (p. 529).

2.3.2 Other Psychological Responses

Some investigations have demonstrated that association is related to longer reaction times (Côté, Salmela, & Papathanasopoulu, 1992) and more response errors, specifically at high heart rates. This has been interpreted as suggestive of "*an internalizing of attention as individuals focus on internal signals of pain and fatigue rather than upon the external stimuli*" (Salmela & Ndoye, 1986). Other studies of cognitive tasks, however, have shown either no decrement (Sacks et al. 1981) or improved performance (Couture et al., 1994). According to some researchers, performance outcomes depend on dissociative complexity (Siegal, Johnson, & Davis, 1981). However, the lack of control for relative exercise intensity also cannot be discounted as a possible reason for the inconsistent results.

Studies of exercise compliance are similarly inconclusive. On the one hand, thematic analysis of case vignettes in a qualitative study showed that both attentional focus strategies would contribute to improved compliance (Stetson et al., 1995). On the other hand, while a dissociative compared to an associative strategy was found to improve both immediate and long-term exercise program adherence (Martin et al., 1984), other evidence suggests that use of internal (i.e., associative) or external (i.e., dissociative) self-statements was unrelated to run distance or adherence at 6 months (Welsh, Labbé, & Delaney, 1991).

2.3.3 Audio-Visual Stimuli and Exercise: Affective Responses

Investigations that have measured affective responses during physical activity using auditory and/or visual stimuli have focused primarily on whether the stimulatory technique produces positive or negative responses. Investigations have examined a variety of affective responses. These include standardized measures of core affect, specific emotional feeling states, and broad mood states. Additional measures of attitudes, participants' thoughts during exercise, perceived bodily symptoms, intrinsic motivation, and motivation towards the music have also been examined as they are thought to be relevant to affective responses.

Audio-visual stimuli are a common strategy for regulating mood and enhancing the overall exercise experience. A number of studies have employed both general and specific measures of affective responses. The results of studies utilizing general mood or enjoyment scales have generally shown equivocal findings, with improvements in mood (Hayakawa, 2000; MacRae et al. 2003; Plante, Alridge et al. 2003; Plante, Frazier et al., in press) and enjoyment (Kendzierski & DeCarlo, 1991; Wininger & Pargman, 2003), as well as mood declines (Crust & Clough, 2006), or no change in mood (Russell et al. 2003) being reported during music and other audio-visual stimuli. For example, Simpson and Karageorghis (2006) reported no differences in mood states during anaerobic exercise across attentional dissociation and control conditions. Likewise, Steptoe & Cox (1988) did not observe any differences on standardized anxiety and mood state measures during exercise at low and high intensity levels with and without music. Similar inconsistencies have been noted in cardiac rehabilitation research (Emery et al. 2003; Murrock, 2002).

Conversely, measures of basic affect (defined simply as ratings of pleasure-displeasure) generally show more positive affective responses (Brownley et al. 1995; Elliott et al. 2004, MacNay, 1995, Murrock, 1995; Robergs et al. 1998; Seath & Thow, 1995), although this may depend on the exercise intensity level and type of stimulus. For example, Boutcher and Trenske (1990) concluded that the effects of music on affective responses during exercise appear to be load-dependent. Specifically, no differences in affect were noted at a workload of 60% HR_{max} for conditions of music, no music, and sensory deprivation. However, at workloads of 75% and 85% HR_{max}, listening to music resulted in significant differences (i.e. more positive) compared to the other conditions.

On the other hand, a different trend emerges when the participant is allowed to select the pace or intensity (which, arguably, does not result in high levels of intensity). Specifically, no improvements in specific feeling states or basic affective responses have been observed during self-paced cycle ergometry during audio-visual stimuli (Annesi & Mazas, 1997; Robergs et al. 1998). For example, MacRae et al. (2003) examined responses on both the Exercise-induced Feeling Scale (Gauvin & Rejeski, 1998) and Subjective Exercise Experiences Scale (McAuley & Courneya, 1994) and found no difference between trained and untrained female cyclists performing 30 min of self-paced cycle ergometry under conditions of video + music and music-only.

Other general psychological measures provide additional insight into the relationship between audio-visual stimuli and the exercise experience. For example, Crust (2004) reported that familiar music tracks were rated as more motivational than unfamiliar music tracks. Moreover, listening to familiar tracks resulted in longer endurance times compared to unfamiliar music during a graded treadmill test. However, it was noted that the "*…mechanism by which music influenced endurance in this study [was] unclear*" (p. 366). Moreover, DeBourdeaudhuji et al. (2002) argued that the longer time to exhaustion in obese adolescents performing a graded treadmill test while listening to music was the result of a longer time to detect bodily sensations severe enough to stop the exercise test.

With regards to evaluating the exercise experience, Elliott et al. (2005) observed that attitudes towards a submaximal exercise experience were more positive both immediately and 24-hours post-exercise with music, regardless of the motivational qualities of the selection, compared to a no music condition. Similarly, Miller and Donohue (2003) noted that individuals using either music or motivational and/or instructional self-statements reported greater perceived improvement in running time and greater perceived satisfaction with each running intervention compared to a control ("No Sound") condition. Tenenbaum et al. (2004), in a series of laboratory and field investigations of running at both self-selected and near-maximal intensities, found that music characterized as "*inspirational*" was reported as more beneficial for tolerating the physical discomfort compared to other genres of music. Moreover, the researchers noted the tendency of the participants' attention to shift from listening to the music to sensations of discomfort of exercising. Finally, evidence suggests that perceived choice of music positively influences intrinsic motivation towards physical activity (Dwyer, 1995). Investigations of individuals with developmental disabilities showing improved mood or greater workloads with music further support the relationship between audio-visual stimulation and physical activity (Lancioni, O'Reilly, Singh, Oliva, Piazzolla, & Groeneweg, 2004; Lancioni, Singh, O'Reilly, Oliva, Campodonico, & Groeneweg, 2003; Lancioni, Singh, O'Reilly, Oliva, Campodonico, & Groeneweg, 2004).

Likewise, meaningful improvements in adherence and dropout as well as longer exercise sessions have been demonstrated with audio-visual stimuli (Annesi, 2001; Annesi & Mazas, 1997). Such improvements seem to suggest an underlying relationship between having a pleasurable exercise experience and being motivated to continue an exercise program. Moreover, this relationship appears to bear out in patients with dementia (Mathews, Clair, & Kosloski, 2001) as well as older individuals undergoing physical therapy rehabilitation (Johnson, Otto, & Clair, 2001; Otto, Cochran, Johnson, & Clair, 1999), and receiving long-term care (Hagen, Armstrong-Esther, & Sandilands, 2003). Murrock (2002) echoed this sentiment by stating "*Compliance with an exercise protocol depends on the degree of pleasure associated with the exercise – the more pleasure perceived, the more likely the exercise will be repeated*" (p. 230).

2.4 Audio-Visual Stimuli and Exercise: Music Preference

Within exercise science, a number of studies have examined music preference as a possible influence on exercise performance. In some cases, the result has been for preferred music to improve exercise performance (Smith & Widmar, 2004). In other studies, the extent to which participants liked a music selection played during exercise had no effect on physiological responses (Roberts et al., 2004). Furthermore, a number of studies have examined the individuals' preference on some characteristic of music. For example, Karageorghis et al. (2006) noted that participants reported a preference for medium (120 bpm) and fast (140 bpm) tempo music while working at 40% and 60% maximal HRR (HRR_{max}). When the exercise intensity level increased to 75% HRR_{max}, however, only the fast tempo music selections were preferred. The authors further suggested that "…*the match of music at an appropriate tempo* during *exercise is most likely to induce positive in-task affect and promote enjoyment*" (p. 248). Likewise, Szabo et al. (1999) examined preferences in music tempo style while cycling against a progressive resistance. The authors noted that most participants preferred either fast music or music that transitioned from a slow to fast tempo during the exercise bout. The finding that the slow to fast music transition is made more noteworthy when one considers that the transition in music tempo occurred at the point the participant exceeded 70% maximal HRR. The authors noted the relative ease of listening to music at low exercise intensity levels. However, as the exercise intensity level increases, there is a concomitant increase in the demand of cognitive attention to internal and external cues. They concluded that music can be an adequate stimulus as long as it is "…*sufficiently arousing to compete with the stimulus of fatigue to distract the exerciser's mental processing*" (p. 223).

2.5.1 Attentional Association and Dissociation and Exercise: Exertional Responses

Ratings of Perceived Exertion (RPE) have been perhaps the most widely studied outcome in investigations examining the effectiveness of A/D strategies (35 out of 88 studies). Perceived exertion represents a *gestalt* of all sensory inputs pertaining to the intensity of exercise. Theoretically, an attentional focus strategy that amplifies physical sensations, as in the case of association, should result in consistently higher perceived exertion ratings. Conversely, any attentional focus strategy that attenuates physical sensations, as in the case of dissociation, should result in consistently lower ratings.

A review of the studies investigating the relationship between A/D strategies and perceived exertion, however, reveals that findings have been inconclusive. In some cases, these results may be due to the confounding influence of gender or uncontrolled individual-difference variables. For example, Wrisberg et al. (1988) reported that, under a self-focused (i.e., associative), low-intensity exercise condition, male participants displayed higher heart rates and lower perceived exertion ratings, whereas female participants exhibited lower heart rates and higher perceived exertion ratings. On the other hand, female participants classified as "*externals*" on a locus-of-control scale (i.e., tended to attribute outcomes to external causes) reliably reported higher perceived exertion ratings across cycle ergometer and treadmill exercise conditions compared to a group of "*internal*" female participants (Hassmèn & Koivula, 1996; Koivula & Hassmèn, 1998).

Some evidence suggests that both associative and dissociative strategies can result in higher perceived exertion ratings. For example, some studies have demonstrated higher perceived exertion ratings during short- (Baden et al., 2005; Tamman, 1996) and long-distance running (Schomer, 1986, 1987a, 1987b, 1990; Schomer & Connolly, 2002) and rowing (Connolly & Janelle, 2003) related to associative strategies or thinking. On the other hand, other studies have shown that dissociative thinking can also result in higher RPE (Brewer, Van Raalte, & Linder, 1996; Russell & Weeks, 1994; Tamman, 1996). Deligniéres and Brisswalter (1994) noted higher perceived exertion scores when participants performed a dissociative task (i.e., reaction time) while cycling at 20%, 40%, 60%, and 80% VO_2max. Conversely, other investigations have noted that dissociation results in lower perceived exertion ratings during running (LaCaille, Masters, & Heath, 2004; Baden, Warwick-Evans, & Lakomy, 2004), cycle ergometry (Johnson & Siegal, 1987; Stanley, Pargman, & Tenenbaum, 2007), moderate-intensity exercise (Deligniéres & Brisswalter, 1994; Baden, Warwick-Evans, & Lakomy, 2004), and various self-paced physical activities (Padgett & Hill, 1989). Several researchers, using self-reported physical symptoms as a complement to perceived exertion, have observed fewer physical symptoms when focusing externally or dissociating compared to associating (Fillingim & Fine, 1986; Pennebaker & Lightner, 1980).

Finally, a number of studies have found no difference in RPE between association and dissociation strategies during swimming (Couture, Jerome, & Tihanyi, 1999; Couture, Tihanyi, & St. Aubin, 2003), outdoor vs. indoor running (Harte & Eifert, 1995), cycling at low, moderate, and high exercise intensities (Fillingim, Roth, & Haley, 1989; Siegal, Johnson, & Davis, 1981; Stamford, Weltman, & Foulke, 1979), self-paced running (Weinberg et al., 1984), and military marching (Couture et al, 1994). Evidence suggests that lower perceived exertion may be related with dissociation at lower and with association at higher exercise intensities (Franks & Myers, 1984; Tenenbaum & Connolly, 2008). In fact, some researchers have suggested that a shift from dissociation to association appears to be initiated around a rating of 13 ("*Somewhat Hard*"; Welch et al. 2007) or when relative exercise intensities exceed 50% of maximal workload (Tenenbaum & Connolly, 2008).

2.5.2 Audio-Visual Stimuli and Exercise: Exertional Responses

Research of auditory-visual stimuli has commonly used perceived exertion ratings (RPE) as a measure of the subjective experience to the exercise bout. As perceived exertion represents a *gestalt* of all sensory inputs, it is of research interest as to whether the subjective experience is altered when the internal sensory inputs compete with external inputs such as auditory (i.e. music) or audio-visual (i.e. video watching) stimuli. Theoretically, any strategy that competes for the limited attentional capacity, as in the case of either listening to music or watching a video during exercise, should result in consistently lower perceived exertion ratings. Alternatively, the absence of a stimulus should result in consistently higher perceived exertion ratings as interoceptive cues have an uninhibited path to the respective processing centers of the brain. A review of the studies investigating the relationship between auditory-visual stimuli and perceived exertion, however, shows the findings to be inconclusive.

Numerous investigations demonstrate that music and other audio-visual stimuli result in lower ratings of effort sense (Bharani et al., 2004; Boutcher & Trenske, 1990; Copeland & Franks, 1991; MacNay, 1995; Nethery, 2002; Nethery et al. 1991; Potteiger et al., 2000;

Seath & Thow, 1995; Smzedra & Bacharach, 1998; Stones, 1980; Thornby et al., 1995). For example, Matesic and Cromartie (2002) reported a significant difference in RPE scores only for a group of untrained runners while listening to music (13.4; 13 = "*Somewhat Hard*") compared to without music (17.5; 17 = "*Very Hard*"). Closer examination of these findings seems to suggest that the results on RPE are relatively stable when comparing music to a metronome (Pujol et al. 1996; Steptoe & Cox, 1988) and across exercise performed at intensities ranging from 75% VO_2max (Fatouros et al. 2005) to volitional exhaustion (Kirby & Murphy, 2003). Pujol et al. (1996), however, observed significantly lower RPE scores with music while exercising at 60% compared to 80% of maximal workload.

An equal number of investigations, however, suggest music (Atkinson et al., 2004; Hayakawa, 2000) and other audio-visual stimuli (Plante, Alridge et al. 2003; Robergs et al. 1998) during physical activity contribute to higher RPE. For example, while music did not have a significant impact on perceived exertion, Edworthy and Waring (2006) did note a pattern for higher RPE scores in both fast and no music conditions and lowest in the slow music conditions. Elliott et al. (2005) observed that RPE remained constant up to min 8 across all music conditions during a 20 min self-paced exercise bout. From min 8 to min 19, however, RPE increased in both music conditions (motivational and oudeterous) whereas it remained stable in the no music condition.

In contrast, a number of researchers have observed no differences in perceived exertion across music or other audio-visual conditions, different testing protocols, and participant characteristics (Abadie et al. 1996; Brownley et al., 1995; Jensen et al., 2000; Loucks, 2000; MacRae et al. 2003; Murrock, 1995; Pfister et al., 1998; Robergs et al. 1998; Russell & Weeks, 1994; Russell et al. 2003; Schwartz et al., 1990; Tenenbaum et al., 2004).

For example, no differences in RPE across different audio-visual conditions have been noted when performing exercise at self-selected intensities (Abraham & Thomas, 1999; MacEneaney et al. 2004), various lactate concentrations (Pujol et al. 1999, 2003), 70% VO_2peak (Goff et al. 1996), 80% VO_2max (Ciccomascolo et al. 1995), or exhaustive exercise (Smith & Widmar, 2004). Similar findings have been noted in investigations of rehabilitative aerobic or physical therapy exercises in that ratings of perceived exertion and pain sensations appear not to be influenced by music (Kim & Koh, 2005; Murrock, 2002). Moreover, Marin-Hernández and Aragón-Vargas (1999) investigated different music decibel levels during exercise at 80% HR_{max} and found no differences in RPE at 70 dB, 85 dB, or no music conditions.

2.6.1 Attentional Association and Dissociation and Audio-Visual Stimuli and Exercise: Exercise Economy

A number of indices of exercise intensity have been used to assess exercise economy within the attentional association and dissociation as well as music and other audio-visual stimulatory condition literature. The most common index has been to measure the cardiovascular response including heart rate (HR), blood pressure (BP), and rate pressure product (RPP). Absolute (HR_{peak}, HR_{max}) and relative ($\%HR_{peak}$, $\%HR_{max}$) values of heart rate have been the most prevalent. Other indices also include measures of oxygen consumption (VO_2), ventilatory (V_E) and respiratory (RR) responses, respiratory exchange ratio (RER), and lactate and hormonal markers of physiological strain.

2.6.1.1 Attentional Association and Dissociation: Heart Rate, Blood Pressure, and Rate Pressure Product

Measuring absolute (HR_{peak}, HR_{max}) or relative (%HR_{peak}, %HR_{max}) heart rate as well as blood pressure while associating or dissociating has been common practice within the attentional focus literature. Twenty-one of the 88 studies have included heart rate data. Findings from studies in which such measures were taken have shown equivocal results. Several investigators have reported no changes in absolute heart rate or blood pressure (Baden et al., 2005; Hatfield et al., 1992; Johnson & Siegal, 1981; Pennebaker & Lightner, 1980; Weinberg et al., 1984) under either association or dissociation conditions. Alternatively, other researchers have observed that association results in lower (Couture et al., 1994) as well as higher (Connolly & Janelle, 2003) heart rate. For example, Rushall et al. (1988) noted significantly higher heart rates while using task-relevant statements (i.e., association) compared to a control condition in a sample of competitive cross-country skiers. Similarly, dissociation has been found to decrease (Couture et al., 1994; Franks & Myers, 1984) as well as increase (Smith et al., 1995) heart rate. For example, Morgan and colleagues (1983) observed lower heart rates during the initial phase (min 5) of an incremental treadmill test under a dissociative condition compared to both placebo and control conditions. These differences, however, were eliminated by the final minute of the test.

2.6.1.2 Music and other Audio-Visual Stimuli: Heart Rate, Blood Pressure, and Rate Pressure Product

A number of studies have demonstrated the tendency for heart rate to increase during physical activity under conditions of music or other audio-visual stimuli above and beyond what might be expected compared to without (Atkinson et al., 2004; Bharani et al., 2004; Copeland & Franks, 1991; Hayakawa et al., 2000; Jensen et al., 2000; Karageorghis, 2000; MacEneaney et al., 2004; Roberts et al., 2004) and remain elevated post-exercise (Beckett,

1990) under various audio-visual conditions. These findings seem to be consistent across exercise performed at intensities ranging from self-selected (Robergs et al. 1998) to volitional exhaustion (DeBourdeaudhuji et al. 2002) and under conditions of different music tempos and volumes (Edworthy & Waring, 2006). Urakawa and Yokoyama (2005) demonstrated that listening to music both pre- and post-exercise increased the ratio of low frequency (LF) to high frequency (HF) component of heart rate variability. The authors concluded that music maintains sympathetic nerve activity initially generated by exercise. This finding is supported, in part, by research demonstrating that periods of silence interspersed between musical excerpts results in selected respiratory and cardiovascular measures to drop below baseline levels (Bernardi, Porta, & Sleight, 2006).

On the other hand, various investigations show no change in heart rate values during exercise within the music (Abraham & Thomas, 1999; Ciccomascolo et al., 1995; Coutts, 1961; Crust, 2004; Emery et al., 2003; Kirby & Murphy, 2003; Loucks, 2000; Potteiger et al., 2000; Schwartz et al., 1990; Seath & Thow, 1995; Smith & Widmar, 2004; Tenenbaum et al., 2004; Thornby et al., 1995; Yamamoto et al., 2003) and audio-visual stimulus literature (Hull & Potteiger, 1999; Nethery, 2002; Plante, Frazier, et al., in press; Russell & Weeks, 1994). Again, these findings seem to remain stable across exercise intensities of 70% VO_2max during cycle ergometry under experimental conditions of music (Goff et al. 1996) and video watching (Robergs et al. 1998). In some cases, stable HR values have been reported despite exercising while listening to music at different decibel levels (Martin-Hernández & Aragón-Vargas, 1999) and music tempos (Gallagher, 1996).

Finally, some researchers have demonstrated lower heart rate during exercise while listening to music (Smedzra & Bacharach, 1998). For example, Matesic and Cromartie

(2002) noted that a group of untrained runners performed a 20-min self-paced run with lower heart rates while listening to music. Alternatively, music did not have an effect on heart rate values for a group of trained runners. Fatouros et al. (2005) reported lower HR during a graded cycle ergometry test to volitional exhaustion while listening to music.

Other indices of cardiovascular strain, such as BP and RPP measures, show similar inconsistencies across investigations. Rate pressure product has been reported to increase (Bharani et al. 2004) as well as decrease (Fatouros et al. 2005) during graded exercise testing with audio-visual stimuli. Similarly, blood pressure has been reported as higher in a group of female adolescents exercising with music (Uppal & Datta, 1990) as well as lower (Emery et al., 2003). The role of exercise intensity and participant fitness level may underlie these inconsistencies. For example, during a music condition, Smedrza and Bacharach (1998) observed lower RPP during min 12 (9%) and min 15 (8.8%) as well as post-exercise (15.4%) and lower systolic blood pressure at min 9 (4.8%) and min 15 (3.6%). However, participants were a group of trained subjects running at submaximal exercise intensities.

2.7.1.1 Attentional Association and Dissociation: Oxygen Consumption

Measures of absolute (VO_2peak, VO_2max) and relative (%VO_2peak, %VO_2max) oxygen consumption are another studied index of exercise intensity level and economy within the A/D literature (6 out of 88 studies). Unlike the conflicting findings on heart rate, results on oxygen consumption have typically shown no effect. Smith and colleagues (1995) found no difference in oxygen consumption ($ml \cdot kg^{-1}$) per kilometer between a control condition and both passive and active association. Morgan et al. (1983) failed to find differences in VO_2max or %VO_2max under dissociation at any stage of an incremental treadmill test. Finally, Hatfield et al. (1992) observed no differences in VO_2 between a feedback (i.e., association), a distraction, and a control condition during a submaximal treadmill run. Only Martin et al. (1995) noted that competitive runners who scored high on a self-attention questionnaire, and therefore could be classified as having a more associative orientation, demonstrated better running economy, defined as lower oxygen uptake relative to body weight (e.g., $ml \cdot kg \cdot min^{-1}$).

2.7.1.2 Music and other Audio-Visual Stimuli: Oxygen Consumption

Most investigations in which oxygen consumption was measured report no differences in oxygen uptake values during audio-visual stimulation (Hull & Potteiger, 1999; Robergs et al. 1998) and listening to music during physical activity (Abraham & Thomas, 1999; Gallagher, 1996; Kirby & Murphy, 2003; Smith & Widmar, 2004). For example, Schwartz et al. (1990) did not find a difference in relative VO_2 values for a sample of untrained participants performing cycle ergometry at 75% VO_2max across various music conditions. This finding appears consistent across studies in which participants are asked to exercise at an RPE of 13 ("*Somewhat Hard*") and 17 ("*Very Hard*"; Roberts et al. 2004) and at a fixed blood lactate concentration of 4.0 $mmol \cdot L^{-1}$ (Pujol et al. 1999).

Alternatively, other studies have reported either lower or higher VO_2 values during audio-visual stimulation. Some investigations have reported lower VO_2 values during exhaustive exercise testing in obese adolescents (DeBourdeaudhuji et al. 2002), exercise at 75% VO_2max (Fatouros et al. 2005), and self-selected intensities (MacEneaney et al. 2004). In contrast, Robergs et al. (1998) demonstrated higher mean VO_2 values while watching a cycling video during 35 min of self-selected cycle ergometer exercise intensity. Likewise, Annesi (2001) reported an improvement in VO_2max values in participants assigned to combination entertainment condition during a 14-week cardiovascular exercise program.

2.8.1.1 Attentional Association and Dissociation: Ventilatory and Respiratory Responses

Ventilatory measures, including minute ventilation (V_E) and ventilatory equivalents (V_E/VO_2, V_E/VCO_2), also provide information as to the exercise intensity level or economy during an exercise bout. In general, it appears that association has a beneficial effect on ventilatory responses (2 out of 88 studies). For example, Hatfield et al. (1992) had participants complete a 36-min submaximal (sub-ventilatory threshold) treadmill run under the conditions of biofeedback, distraction (reaction time task), and control. The researchers observed significant differences in numerous ventilatory variables between the feedback and other conditions. Specifically, the feedback condition elicited lower V_E/VO_2, V_E ($l \cdot min^{-1}$), respiration rate, tidal volume, and pressure of end-tidal oxygen and carbon dioxide compared to the other conditions. These results confirmed an earlier study by Hatfield, Spalding, Mahon, Brody, and Vaccaro (1986), in which an associative strategy (visual feedback of ventilatory responses) resulted in significantly lower V_E/VO_2 compared to both a control and a dissociative condition. Collectively, these results prompted the researchers to suggest a link between associative coping strategies and ventilatory efficiency and to conclude that "*psychological processes may alter metabolic efficiency during intense activity*" (p. 441).

Attempts have been made to design interventions aimed at helping runners tune into their ventilatory responses. Simes (1982) developed a cognitive coping strategy that incorporated both associative and dissociative elements (Pace-Assisted Dissociation/Association; PADA) in addition to running mechanics. This strategy involved the "*coordination of respiration with stride frequency with continuous attention to it maintained by counting respirations*" (p. 2). This strategy was thought to be most beneficial during uphill running to avoid the transition into anaerobic supplementation. Simes (1982) stated, "*By keeping the respiration and stride frequency in synchrony on the uphill grade, the runner naturally shortens the stride length and thus stays closer to anaerobic threshold or the optimum metabolic workload*" (p. 2).

2.8.1.2 Music and other Audio-Visual Stimuli: Ventilatory and Respiratory Responses

Ventilatory and respiratory responses provide an important marker for gauging differences in effort, particularly in clinical populations. To this end, a number of subjective and objective ventilatory measures have been used in investigations of audio-visual stimuli and exercise. For example, music was found to have no effect on perceived dyspnea in a group of COPD patients during exercise (Pfister et al., 1998). Likewise, Schwartz et al. (1990) observed similar minute ventilation (V_E) values between untrained men and women across experimental music conditions during submaximal cycle ergometry. Uppal and Datta (1990) demonstrated that exercising across music conditions did not significantly influence various cardiopulmonary indices in healthy adolescent girls. Alternatively, MacEneaney et al. (2004) noted that the exercise intensity relative to the ventilatory threshold was higher with music compared to without music during self-selected exercise intensity. Brownley et al. (1995) found that fast music resulted in increased respiration rate and that minute ventilation was increased for untrained participants only during the fast music condition.

2.9.1.1 Attentional Association and Dissociation: Respiratory Exchange Ratio

Another index of exercise economy that has received little attention in the A/D literature (2 out of 88 studies) is the respiratory exchange ratio (RER). This measure provides another index of exercise economy by highlighting the relative contribution of either carbohydrate or fat oxidation towards energy expenditure. Despite the relatively few studies that have included this measure, there appears to be support for an associative strategy resulting in a lower ratio (i.e., higher percentage of fat oxidation). For example, Hatfield and colleagues (1992) reported significantly lower RER values in participants using biofeedback (i.e., association) compared to either a distraction or a control condition during a run just below the ventilatory threshold. In a similar study, Smith et al. (1995) observed that the most economical runners (those showing lower HR, V_E, and RER) reported significantly less use of dissociation compared to the least economical runners. However, the most and least economical runners did not differ in the use of association. As in many other studies in this literature, intensity was not precisely controlled.

2.9.1.2 Music and other Audio-Visual Stimuli: Respiratory Exchange Ratio

Measuring the respiratory exchange ratio (RER) provides another method for detecting the relative physiological strain of an exercise bout. Interestingly, few investigations report RER data. Of the studies that do report RER, the findings appear mixed. Some research suggests that there is no change in RER values across audio-visual stimulatory conditions (Schwartz et al., 1990). For example, Roberts et al. (2004) noted no difference in RER when the workload was set at an RPE of 13 or 17 for trained participants regardless of whether participants liked or disliked the music selection. Kirby and Murphy (2003), however, observed a lower RER during a music condition compared to a no music condition when female participants first performed a 6 min submaximal run and then completed a run to exhaustion. Conversely, DeBourdeaudhuji et al. (2002) observed increases in RER values from pre- to post-test for both music and no music conditions for obese adolescents performing a graded exercise test.

2.10.1.1 Attentional Association and Dissociation: Blood lactate, glucose, and stress hormones

To date, only one known study has examined the influence on A/D strategies on stress hormone markers. To examine the effects of differences in attentional focus on the stress hormone response, Harte and Eifert (1995) had participants run outdoors (dissociation), or indoors on a treadmill for 45 min with either an internal (association) or external (dissociation) focus. The researchers noted that epinephrine did not appreciably differ between conditions, but that both cortisol and norepinephrine were higher under the indoor-internal focus condition. Moreover, participants rated the indoor-internal focus as least pleasing compared to the other conditions. However, the results are confounded by a notable limitation of the study. Specifically, exercise intensity was not controlled and, therefore, the effects of the physical stress of exercise and the A/D intervention could not be teased apart.

2.10.1.2 Music and other Audio-Visual Stimuli: Blood lactate, glucose, and stress hormones

Measuring metabolic byproducts or stress response markers also elucidate the influence of audio-visual stimulation on the degree of exercise economy. Cortisol has been shown to increase during exercise when listening to music (Brownley et al., 1995) while investigations measuring epinephrine and/or norepinephrine have shown either no change (Yamamoto et al., 2003) or lower values (Smedzra & Bacharach, 1998). Fatouros et al. (2005) noted lower norepinephrine, but not epinephrine or β-endorphin, values at the end of exhaustive exercise while listening to music.

Blood lactate and blood glucose levels provide both direct and indirect measures of physiological strain during exercise. While investigations measuring blood glucose appear to consistently show no differences across music conditions (Fatouros et al. 2005; Kirby &

Murphy, 2003), studies on blood lactate show more varied results. Smedzra and Bacharach (1998) observed lower blood lactate levels in a group of trained runners performing a 15-min treadmill run at 70% VO_2max while listening to classical music and this finding is consistent with other investigations (Smith & Widmar, 2004). Conversely, Fatouros et al. (2005) reported greater blood lactate levels at the end of a treadmill run at 75% VO_2max to exhaustion under a music condition. Finally, a number of studies have found no changes in blood lactate levels under different music (Gallagher, 1996; Kirby & Murphy, 2003; Schwartz et al., 1990; Yamamoto et al., 2003) or audio-visual (Robergs et al. 1998) stimulatory conditions. Although blood glucose measures appear stable across studies, drawing conclusions on the effects of music based on a more common measure of the metabolic costs of exercise, blood lactate, appears more difficult.

2.11 Audio-Visual Stimuli and Exercise: Summary

Findings from the broader A/D literature and more specific A-V research realm have yielded a wide range of outcomes. These inconsistent results may stem from issues pertaining to participant characteristics, the exercise stimulus, selection of the audio-visual stimulus, and a lack of theory-derived hypotheses. Based on the extant literature, certain preliminary conclusions can be drawn. First, a majority of A/D studies used healthy, fit college-aged participants (36 out of 71 studies; 50.7%). Similarly high percentages were found for studies of audio-visual stimuli (~86%), audio-only stimuli (~70%), and visual-only stimuli (67%). Attentional dissociation strategies are often suggested for physically inactive individuals as a means of better tolerating the stress of physical exertion, yet it seems inadvisable to base such a recommendation on findings from studies with young, fit individuals. Second, exercise intensity levels appear to have been selected arbitrarily and spanned the full range of exercise intensities: self-selected (10 out of 71 A/D studies; 14.1%; 21 out of 92 A-V studies; ~23%); submaximal (33 out of 71 studies; 46.5%; 38 out of 92 A-V studies; ~41%); exhaustive (16 out of 71 studies; 22.5%; 26 out of 92 A-V studies; ~28%). Use of an attentional dissociation strategy implies that there is a need for an external cue to compete with an internal cue (e.g., *competition of cues* paradigm). This argument, in turn, requires the identification of an exercise intensity level sufficient to elicit an internal cue strong enough (e.g., above the ventilatory threshold) to compete with the external cue. Third, participants attended to pre-selected audio-visual stimuli in a majority of studies (53 out of 71 studies; 74.6%). As summarized in the section on *Music Preference*, it seems reasonable to assume that experimenters may not always provide a dissociative audio-visual stimulus that is to the participants' liking and this may influence the outcome.

The most critical oversight, however, is the lack of a theoretical basis for the proposed relationship between music and other audio-visual stimuli, affective responses and exercise performance, prompting numerous researchers to call for (a) more systematic research (Zatorre, 2003) and (b) the use of theoretical paradigms (Crust, 2004; Edworthy & Waring, 2006; Karageorghis & Terry, 1997; Priest, Karageorghis, & Sharp, 2004; Simpson & Karageorghis, 2006; Szabo, Small, & Leigh, 1999). Similar concerns have been echoed within the broader attentional association-dissociation literature (Masters & Ogles, 1998). Collectively, these issues undermine a clearer understanding of the effectiveness of music and other audio-visual stimuli in attenuating the physiological strain and/or enhance the affective responses both during and after exercise.

The proposed study will attempt to rectify these limitations in a number of critical ways. First and most importantly, the study distinguishes itself from past research in that it is theory-driven. Second and related to the first point, the underlying theory allows for specific hypotheses to be generated that describe the relationship between exercise intensity, affective responses, and the influence of audio-visual stimulation. Finally, the confounding issues of sample characteristics and pre-determined audio-visual stimuli were addressed by allowing a sample of physically inactive individuals to self-select a music DVD.

CHAPTER 3. METHODS AND PROCEDURES

This study examined the influence of audio-visual stimulation on affective responses during graded cycle ergometer exercise. Specifically, in accordance with the Dual Mode Model, affective responses are thought to be influenced by cognitive factors across a range of exercise intensity levels. During graded cycle exercise under a control condition (i.e. sensory deprivation), affective responses are predicted to remain stable and positive at low and moderate exercise intensity levels (i.e. below the ventilatory threshold) before initiating a curvilinear decline at intensities above the ventilatory threshold. During an attentional associative condition (i.e. biofeedback), affective responses are predicted to be more negative at low and moderate exercise intensity levels, and show a dramatic decline at higher exercise intensity levels. Conversely, during graded cycle exercise under an attentional dissociative condition (i.e. audio-visual stimulation), affective responses are predicted to remain positive at low and moderate exercise intensity levels, and display a delay in decline towards more negative affect at high exercise intensity levels.

METHOD

3.1 Participants

Thirty-four participants (17 men, 17 women) were recruited from Iowa State University undergraduate and graduate classes as well as the surrounding university and local communities. Participants were between the ages of 18 to 35 years old, healthy, but physically inactive, non-smokers, and not associated with a NCAA-sanctioned athletic team. Participants reported no known medical contraindications to participating in vigorous physical activity as measured by the Physical Activity Readiness Questionnaire (PAR-Q).

Approval to conduct the study and informed consent paperwork was obtained through the Iowa State University Institutional Review Board for the protection of human subjects.

3.2 Instrumentation

Informed Consent form (Appendix A). This document was used to inform the participants of the research study, their rights as a participant in a research study, how their information would be handled, and the amount and process for reimbursement for their participation in the study.

Demographic profile (Appendix B). This document was used to obtain basic demographic information including: participant's name, age, gender, and frequency and intensity of regular physical activity as well as preference for listening to music during exercise. Music preference was measured with a 10-point Likert-type scale where 0 = a low preference for listening to music during exercise and 10 = a high preference for listening to music during exercise.

3.3 Measures

Feeling Scale (Appendix C). Affective responses were assessed using the Feeling Scale (FS; Hardy & Rejeski, 1989). The FS is a single-item, 11-point measure of affective valence (pleasure/displeasure), ranging from +5 to -5, with verbal anchors at all odd integers and at the zero point (+5 = *very good*, +3 = *good*, +1 = *fairly good*, 0 = *neutral*, -1 = *fairly bad*, -3 = *bad*, -5 = *very bad*). All participants read standardized instructions to insure they understood the nature and response options of the scale.

Felt Arousal Scale (Appendix C). Perceived activation was measured using the Felt Arousal Scale (FAS) of the Telic State Measure (Svebak & Murgatroyd, 1985). The FAS is a single-item measure of perceived activation, with participants asked to rate themselves on a 6-point scale ranging from *low arousal* (1), to *high arousal* (6). All participants read standardized instructions to insure they understood the nature and response options of the scale.

Perceived Exertion (Appendix C). Effort sense was measured using the Rating of Perceived Exertion scale (RPE; Borg, 1998) and served as a manipulation check. The scale provided a measure of whole-body ratings of perceived exertion during graded cycle ergometer exercise. The RPE is a 15-point scale ranging from 6 (*No exertion at all*) to 20 (*Maximal exertion*). All participants read standardized instructions to insure they understood the nature and response options of the scale.

Attentional Focus Scale (Appendix C). Participants rated on a 10-point bipolar scale to what extent their thoughts were primarily associative or dissociative during a graded cycle ergometer exercise test. This scale also served as a manipulation check. Visual assessment was facilitated by separating the 10 points that make up the line and representing them as large blocks to which the participant will point during exercise. The data were presented in terms of a 10-point scale, where the first point on the scale = 1 (very associative) and the last point = 10 (very dissociative). Participants were fully briefed in the distinction between associative and dissociative thoughts, and all participants completed a brief manipulation check before commencing exercise to ensure that they were comfortable with the distinction.

Physical Activity Enjoyment Scale (Appendix D). Exercise enjoyment was measured following a bout of exercise using the Physical Activity Enjoyment Scale (PACES; Kendzierski & DiCarlo, 1991). The PACES is an 18-item questionnaire. Participants rated their exercise enjoyment by selecting the degree of agreement to opposing statements on a 7-point Likert type scale.

Heart Rate. Heart rate was assessed with a heart rate monitor (Polar Electro Oy, Finland), consisting of a stretchable chest band and a radio transmitter interfaced to a computer program and metabolic analysis system (see below).

Oxygen Consumption. Oxygen uptake (VO_2) and carbon dioxide (CO_2) excretion was assessed with an open-circuit computerized spirometry system (model TrueMax 2400, ParvoMedics, Salt Lake City, UT). The system consists of a paramagnetic O_2 analyzer, an infrared CO_2 analyzer, and a pneumotachometer (model 3813, Hans Rudolph, Kansas City, MO) to measure ventilation. The system was calibrated prior to exercise testing for O_2 and CO_2 using a gas with certified concentrations of O_2 and CO_2 and for ventilation using a standard 15-stroke calibration procedure, using a 3-L syringe (model 5530, Hans Rudolph, Kansas City, MO).

3.4 Equipment

Graded Cycle Ergometer Exercise Testing. Graded cycle ergometer exercise testing was conducted using a computer-controlled electro-magnetically braked recumbent cycle ergometer (Corival V2, Lode BV, Groningen, The Netherlands).

3.5 Procedure and Research Design

Participants entered the exercise psychology laboratory and were seated in a comfortable chair. Participants were then fitted with a face mask and heart rate monitor. For all gas collection procedures, participants breathed through a nasal and mouth breathing face mask (model 8920/30, Hans Rudolph, Kansas City, MO) equipped with an ultra-low-resistance, T-shaped, two-way, non-rebreathing valve (model 2700, Hans Rudolph). The face mask was connected to the spirometry system via plastic tubing (3.5 cm in diameter). A gel sealant (model 7701, Hans Rudolph) was applied to the face mask to prevent air leaks. Once the face mask and heart rate sensor were securely in place, participants responded to post-mask measures of FS and FAS. Participants then sat on the cycle ergometer and adjusted the seat to a distance that allowed for comfortable pedaling.

Participants began the test by sitting quietly on the cycle for two min while resting HR and VO_2 were determined. Following this, participants began cycling in a recumbent position at a cadence of >50 rev·min^{-1} (rpm). The warm-up period lasted three minutes, while the pedaling resistance remained constant at 30 watts. At the end of warm-up (min 2:45), participants responded to FS, FAS, and RPE. The work rate of the incremental test increased as a linear function of time at a rate of 15W·min^{-1}, during which participants were instructed to maintain a pedaling cadence at a level at which they felt comfortable, but not < 50 rpm. During the graded cycle ergometer test, measures of FS, FAS, and RPE were collected at 1 min intervals. Additionally, participants responded to the Attentional Focus Scale starting at min 2 of the exercise testing protocol and this process was repeated every other min (min 4, min 6, min 8, etc) thereafter to volitional exhaustion.

Two experimental conditions consisting of an attentional associative and attentional dissociative condition were examined in this study. The experimental conditions were counterbalanced and each test consisted of the same exercise protocol; i.e., a graded cycle ergometer exercise test. During an attentional associative condition, a small microphone was inserted into the facemask and participants wore headphones (Ultrasone S-Logic PROline 550 natural surround sound headphones; Germany) allowing them to hear their own breathing at a standardized volume of approximately 80 dB. Heart rate data were also displayed graphically in real time on a 42-inch monitor (Westinghouse 42” 1080p, model LVM-42w2) positioned approximately 2 m in front of the cycle ergometer and approximately at eye level. The immediate testing area was enclosed with black cloth to cover the entire visual field so that all other visual data besides the monitor were eliminated. During an attentional dissociative condition, participants wore headphones and a music DVD of their choice was played on the 42-inch monitor. During each experimental condition, sound volume was standardized to a volume of approximately 80 dB using a sound-level meter. A sensory deprivation condition consisted of a graded cycle ergometer exercise test. During this test, the 42-inch monitor remained blank and participants wore both foam earplugs (Flents Quiet Time, Apothecary Products, Inc.) and sound-attenuating headphones (Remington M-31, Radians, Inc.). The noise reduction ratings for the ear plugs and ear muffs were 30 dB and 31 dB, respectively.

The graded cycle ergometer exercise test was terminated upon the participant's signal of exhaustion or attainment of a VO_2 max. The criteria for achieving VO_2 max was the attainment of at least two of the following three criteria (a) RER ≥ 1.1; (b) a plateau of VO_2 with increasing exercise intensity; and (c) heart rate reached participants' age predicted maximal value (220-age), or (d) participants could no longer maintain a cadence of >50 rpm. Once the cycle ergometer test was terminated, participants responded to post-exercise measures of FS and FAS.

A cool-down period commenced after post-exercise measures had been completed. The cool-down period lasted 5 min, during which the attentional manipulation was still in effect, and participants pedaled at a constant resistance of 30 watts. Additionally, to insure the safe recovery of the participants, heart rate and arterial oxygen saturation were continuously monitored. Participants then responded to post-cool down measures of FS and

FAS. Once these measures were completed, the face mask was removed and any experimental manipulation was stopped.

Following the cool-down period, participants were assisted from the bike to a comfortable chair and administered the PACES. During the 30-min recovery period, participants responded to measures of FS and FAS at 10 min intervals. At the end of the recovery period, the heart rate sensor was removed and collected, and the participant was allowed to leave.

3.6 Statistical Analysis

Five participants experienced technical difficulties with the audio feedback part of the attentional association condition and they were excluded from all statistical analyses. Descriptive statistics for all variables were calculated on the remaining participants (N = 29). The data from the graded cycle ergometer exercise tests was first reorganized to reflect nine time points: post-mask, the first 2 minutes of exercise, the minute before the ventilatory threshold, the minute of the ventilatory threshold, the two minutes after the ventilatory threshold, and the last two minutes of exercise. Changes in FS were analyzed with a repeated-measures multivariate analysis of variance (RM-MANOVA) with attentional focus as an experimental condition (3 levels; Sensory Deprivation [SD]; Biofeedback [BF], and Music-Television [MTV]) and time (9 time points; post-mask, first 2 minutes of exercise, the minute before the ventilatory threshold, the minute of the ventilatory threshold, the 2 minutes after the ventilatory threshold, and the last 2 minutes of exercise). Whenever the sphericity assumption was violated, the conservative Greenhouse-Geisser correction was applied to the degrees of freedom and adjusted probability levels are reported for all repeated measures analyses. Significant main effects of time were followed up with Bonferonni-corrected time-point to time-point pairwise comparisons, with data collapsed across the three conditions. Significant main effect of condition were followed up by one-way ANOVAs (3 levels: SD, BF, MTV), with data from all time points within each condition collapsed. Significant interactions were followed up by separate RM-ANOVAs for each condition (to examine if changes over time were significant for each condition) and then by Bonferroni-corrected pairwise comparisons within each condition (to isolate significant time-point to time-point changes) and separate one-way ANOVAs by condition (3 levels: SD, BF, MTV) at each time point. Effect sizes were computed as $d = M_i - M_j/SD_{pooled}$.

To examine changes in post-exercise affective valence, FS data were analyzed with a repeated-measures multivariate analysis of variance (RM-MANOVA) with attentional focus as an experimental condition (3 levels: SD, BF, MTV) and time (5 time points; post-exercise; post-cool down; minutes 10, 20, and 30 of the recovery period). Whenever the sphericity assumption was violated, the conservative Greenhouse-Geisser correction was applied to the degrees of freedom and adjusted probability levels are reported for all repeated measures analyses. Significant main effects of time were followed up with Bonferonni-corrected time-point to time-point pairwise comparisons, with data collapsed across the three conditions. Significant main effect of condition were followed up by one-way ANOVAs (3 levels: SD, BF, MTV), with data from all time points within each condition collapsed. Significant interactions were followed up by separate RM-ANOVAs for each condition (to examine if changes over time were significant for each condition) and then by Bonferroni-corrected pairwise comparisons within each condition (to isolate significant time-point to time-point changes) and separate one-way ANOVAs by condition (3 levels: SD, BF, MTV) at each time point. Effect sizes were computed as $d = M_i - M_j/SD_{pooled}$. Perceived exercise enjoyment, as measured by the PACES, was assessed post-cool down. Data were analyzed using an analysis of variance by condition (3 levels: SD, BF, MTV). The significance level used in this study was set at $p \leq 0.05$. Finally, gender differences in participant demographic and anthropometric characteristics were analyzed using an independent *t*-test. Significance was defined as $p \leq 0.05$.

CHAPTER 4. RESULTS

4.1 Participant Demographic, Anthropometric, and Performance Characteristics

4.1.1 Age, Body Mass Index (BMI), and Music Preference

A series of independent *t*-tests were performed separately on age, height (cm), weight (kg), body mass index (BMI), percent body fat (%BF), and music preference across gender to determine any differences. Descriptive statistics are found in Table 1. Results indicated no difference between male (M) and female (F) participants on age, $t\ (27) = .244$, $p = .809$, BMI, $t\ (27) = -1.189$, $p = .245$, and music preference, $t\ (27) = .960$, $p = .346$. As expected, however, the results indicated significant differences between gender for height, $t\ (27) = -5.293$, $p = .001$, weight, $t\ (27) = -4.239$, $p = .001$, and percent body fat, $t\ (27) = 6.702$, $p = .001$. The results suggest that male and female participants were similar in age, body mass index, and their degree of preference for listening to music during exercise, but that male participants were taller, and heavier, and had a lower percentage of body fat compared to the female participants.

Table 1. Participant demographic and anthropometric characteristics.

	Male (n = 16)	Female (n = 13)	Overall (N = 29)
Age (y)	22.4±3.3	22.1±3.2	22.2±3.2
Height (cm)	179.4±5.8	166.7±7.2*	173.7±9.1
Weight (kg)	75.4±10.5	61.5±5.9*	69.2±11.1
Body Mass Index (kg/m^2)	23.3±3.1	22.2±1.9	22.8±2.7
% Body Fat	13.5±4.1	26.0±5.9*	19.1±8.0
Music Preference	6.1±1.5	6.6±1.4	6.3±1.5

All values are means±SD. *Significantly different between gender at $p \leq 0.001$.

4.2 Experimental Manipulation Check

4.2.1 Attentional Focus

To test for differences in attentional focus (AF) across the three experimental conditions, a 3 (condition: SD, BF, MTV) by 5 (time: Min 2, pre-VT, VT, post-VT, End) repeated-measures analysis of variance (ANOVA) was used. Because the moment of the VT varied across participants, a 2nd-order polynomial was fitted to the participants' data to identify the predicted AF response at the moment of the VT. The findings for attentional focus are presented graphically in Figure 1. The results for AF showed significant main effects for both condition, $F(2, 54) = 24.816$, $p = .001$, $\eta^2 = .479$, and time, $F(1.178, 46.375) = 38.889$, $p = .001$, $\eta^2 = .590$, and a condition by time interaction, $F(4.474, 120.800) = 4.885$, $p = .001$, $\eta^2 = .153$. A trend analysis also indicated a significant quadratic pattern for condition, $F(1, 27) = 39.020$, $p = .001$, $\eta^2 = .591$, a significant linear patter for time, $F(1, 27) = 60.866$, $p = .001$, $\eta^2 = .693$, and a significant quadratic pattern for the condition by time interaction, $F(1, 27) = 21.852$, $p = .009$, $\eta^2 = .229$. Based on follow up Bonferroni-corrected pairwise comparisons within each condition at each time point, the results showed that AF decreased significantly at each time point for all conditions (ps ≤ 0.05). A series of separate analyses of variance by condition (3: SD, BF, MTV) at each time point revealed significant differences between MTV and both the SD and BF conditions throughout the exercise test (all ps ≤ 0.05).

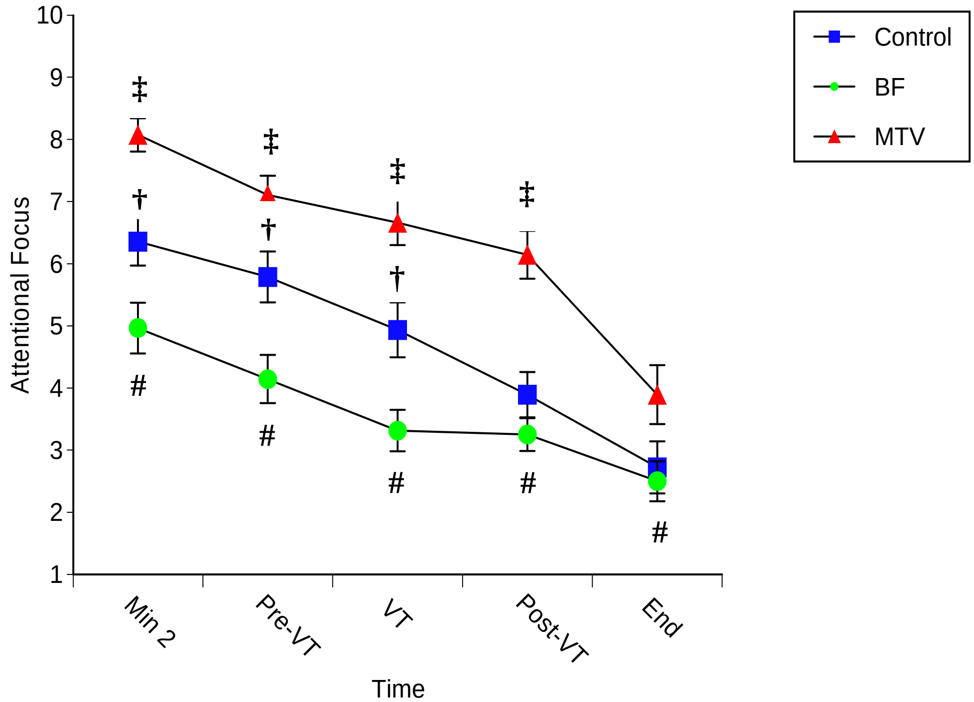


Figure 1. Line graph of attentional focus across experimental conditions of Sensory Deprivation (absence of visual and auditory feedback), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time effect ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: † = Sensory Deprivation and Biofeedback; ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

4.2.2 Perceived Exertion

Exertional responses were analyzed using a 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA). The findings for ratings of perceived exertion are presented graphically in Figure 2. The results showed significant main effects for both condition, $F(2, 56) = 3.262$, $p = .046$, $\eta^2 = .104$, and time, $F(2.496, 69.892) = 394.203$, $p = .001$, $\eta^2 = .934$. However, the condition by time interaction was not significant, $F(4.985, 139.574) = .657$, $p = .656$. Follow up Bonferroni-corrected pairwise comparisons across each time point revealed a significant increase starting from Warm Up to Min 1 and at each subsequent time point thereafter. An analysis of variance by condition (3: SD, BF, MTV), with data from all time points within each condition collapsed, revealed a significant differences between the MTV and SD conditions (p ≤ 0.05).

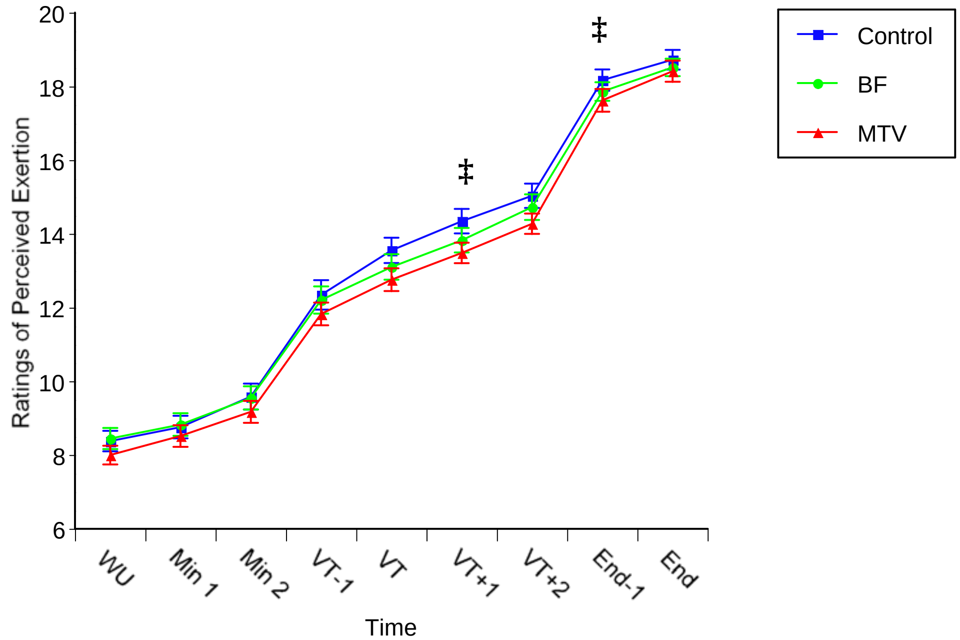


Figure 2. Line graph of perceived exertion across experimental conditions of Sensory Deprivation (absence of visual and auditory feedback), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time effect ($p \leq 0.05$). ‡ = significant differences between Sensory Deprivation and Music-Television conditions ($p \leq 0.05$).

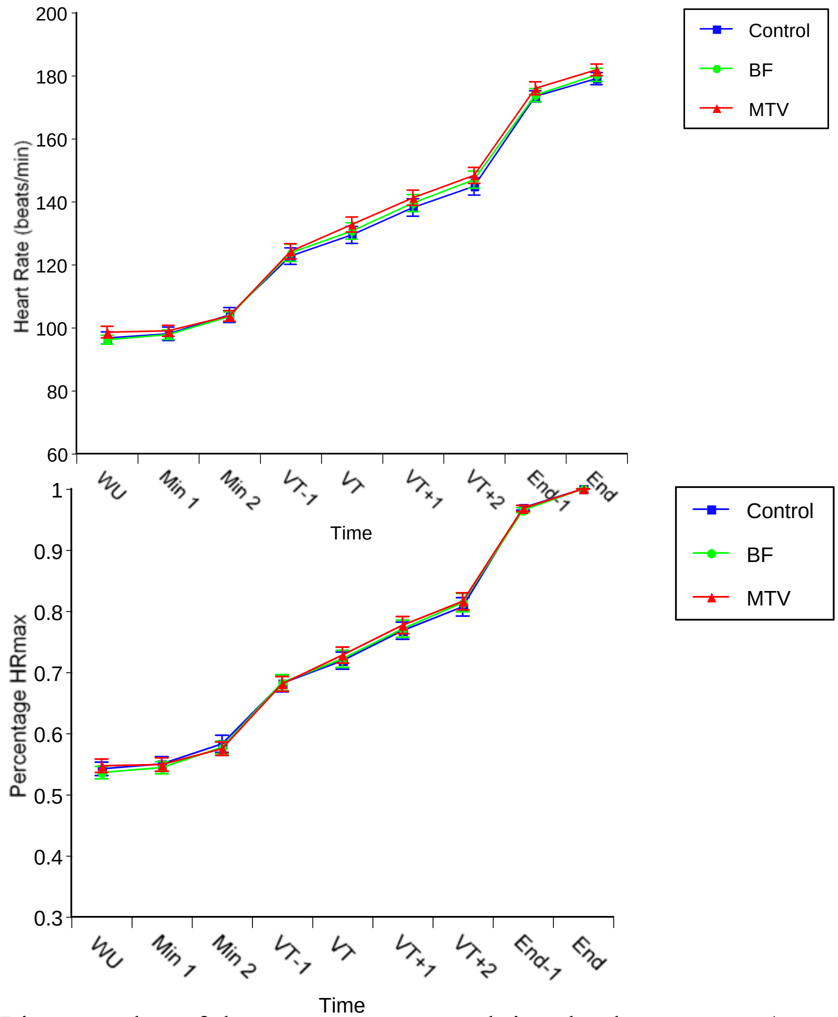
4.3 Exercise Intensity Check

4.3.1 Heart Rate

A 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA) was used to assess differences in heart rate (HR) between conditions across time points. The findings for HR are presented graphically in Figure 3a. The results for HR (beats per minute; bpm) showed a non-significant main effect for condition, $F(2, 54) = 1.061$, $p = .353$, and a non-significant condition by time interaction, $F(3.877, 104.691) = .454$, $p = .764$. However, as expected, there was a significant main effect for time, $F(2.394, 64.645) = 609.983$, $p = .001$, $\eta^2 = .958$. Follow up Bonferroni-corrected pairwise comparisons for each of the nine time points revealed that there was a significant increase in heart rate across each condition starting from Min 2 up to volitional exhaustion (all *p*s = .001).

A 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA) was used to assess differences in percentages of maximal heart rate (%HR_{max}) between conditions across time points. The findings for %HR_{max} are presented graphically in Figure 3b. The results for %HR_{max} showed a non-significant main effect for condition, $F(2, 54) = 0.078$, $p = .925$, and a non-significant condition by time interaction, $F(3.772, 101.833) = 0.384$, $p = .809$. However, as expected, there was a significant main effect for time, $F(2.362, 63.780) = 719.874$, $p = .001$, $\eta^2 = .964$. Follow up Bonferroni-corrected pairwise comparisons for each of the nine time points revealed that there was a significant increase in percentage of maximal heart rate across each condition starting from Min 2 up to volitional exhaustion (all *p*s = .001).

a) b)



Figures 3a-b. Line graphs of heart rate expressed in absolute terms (top panel) and as a percentage of maximal heart rate (bottom panel) across the experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time effect for each graph ($p \leq 0.05$).

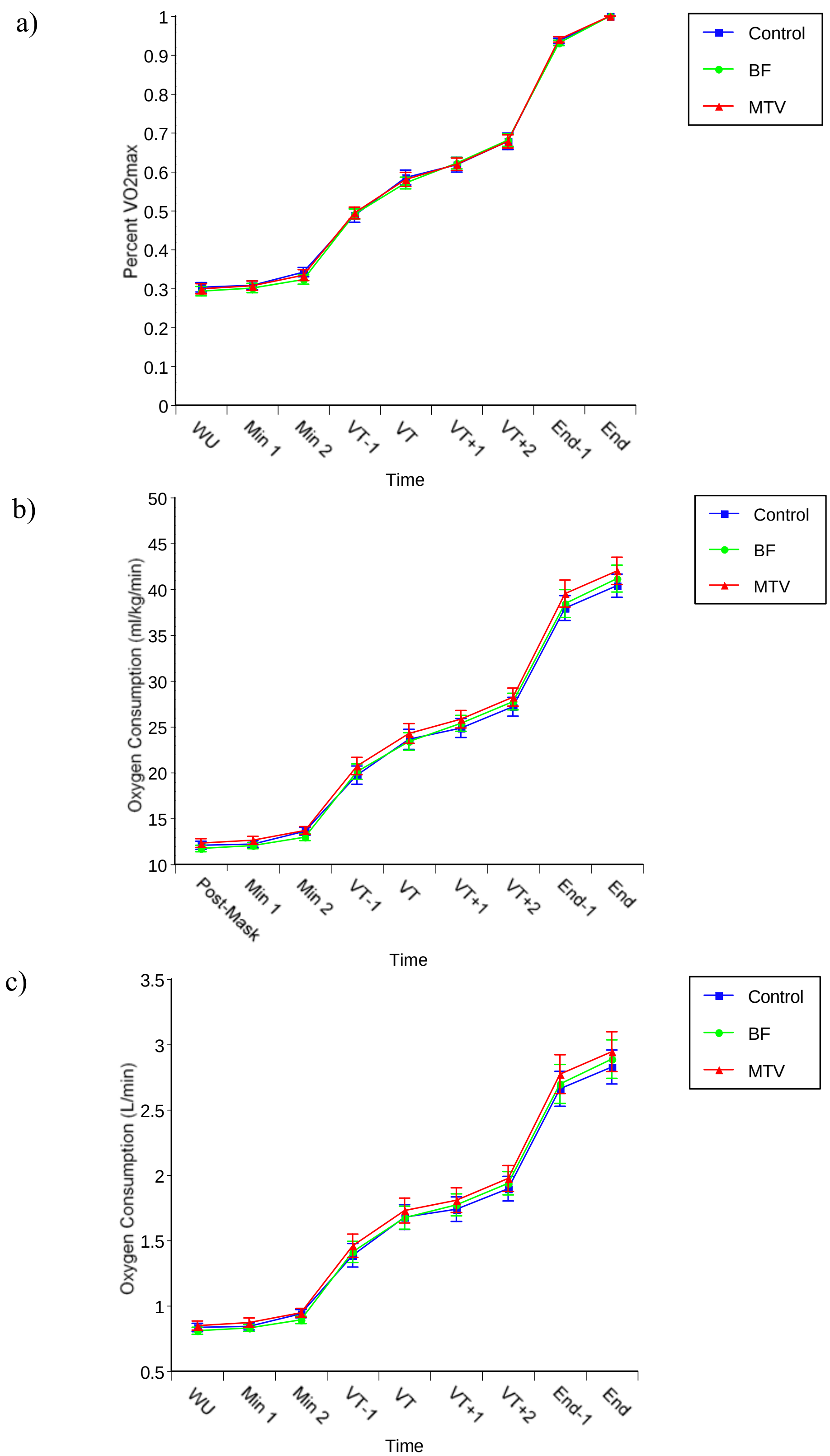
<u>*4.3.2 Oxygen Consumption*</u>

Oxygen consumption (VO_2), measured in absolute terms ($L^{\cdot}min^{-1}$) was analyzed using a 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA). The findings for VO_2 ($L^{\cdot}min^{-1}$) are presented graphically in Figure 4a. The results for absolute VO_2 showed a non-significant main effect for condition, $F(2, 56)$

= 1.631, p = .205, and a non-significant condition by time interaction, F(3.891, 108.955) =.986, p = .417. However, as expected, there was a significant main effect for time, F(1.331, 37.261) = 303.379, p = .001, η^2 = .887. Follow up Bonferroni-corrected pairwise comparisons for each of the time points revealed that there was a significant increase in absolute oxygen consumption across each condition starting from Min 2 up to volitional exhaustion (all ps = .001).

Relative oxygen consumption, measured relative to body weight ($ml \cdot kg \cdot min^{-1}$), was analyzed using a 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA). The findings for VO_2 ($ml \cdot kg \cdot min^{-1}$) are presented graphically in Figure 4b. The results for relative oxygen consumption showed a non-significant effect for both condition, F(1.693, 55.869) = 2.056, p = .144, and condition by time interaction, F(3.690, 121.770) =.989, p = .412. However, as expected, there was a significant main effect for time, F(1.440, 47.522) = 381.068, p = .001, η^2 = .920. Follow up Bonferroni-corrected pairwise comparisons revealed that there was a significant increase in relative oxygen consumption across each condition starting from Min 2 up to volitional exhaustion (all ps = .001).

A 3 (condition: SD, BF, MTV) by 9 (time points: Warm Up, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA) was used to assess differences in percentages of peak oxygen consumption (%VO_2peak) between conditions across time points. The findings for %VO_2peak are presented graphically in Figure 4c. The results for %VO_2peak showed a non-significant main effect for condition, F(2, 66) = 0.177, p = .838, and a non-significant condition by time interaction, $F(3.627, 119.676) = 0.570$, $p = .668$. However, as expected, there was a significant main effect for time, $F(2.176, 71.802) = 1158.135$, $p = .001$, $\eta^2 = .972$. Follow up Bonferroni-corrected pairwise comparisons for each of the nine time points revealed that there was a significant increase in percentage of peak oxygen consumption across each condition starting from Min 2 up to volitional exhaustion (all *p*s = .001).



Figures 4a-c. Line graphs of oxygen consumption expressed as a percentage of peak oxygen consumption (top panel), relative to body weight (middle panel), and in absolute terms (bottom panel). Significant time effect for each graph ($p \leq 0.05$).

4.4 Performance Measures

4.4.1 Time to Exhaustion and Peak Power Output

A series of analyses of variance (ANOVAs) by condition (SD, BF, MTV) were performed for the performance measures of time to exhaustion and peak power output. The findings for these performance measures are presented in Table 2. The results showed a non-significant effect of condition for both time to exhaustion, $F(2, 56) = 2.780$, $p = .071$, $\eta^2 = .090$, and peak power output, $F(2, 56) = 2.185$, $p = .122$, $\eta^2 = .072$. Time to exhaustion, measured in minutes (min), and peak power output, measured in Watts, was not statistically different across the three experimental conditions. The results suggest that participants reached volitional exhaustion at approximately the same time and at against approximately the same pedaling resistance in all three experimental conditions.

Table 2. Descriptive statistics for peak power output (Watts) and exercise time (mins) by gender and overall. Values are Mean±SD.

	Power Output (Watts)	Exercise Time (mins)
Men		
SD	256.8±38.9	15.6±2.7
BF	261.6±47.6	15.9±3.2
MTV	265.5±39.1	16.2±2.5
Women		
SD	176.7±22.1	10.3±1.6
BF	179.0±22.6	10.2±1.4
MTV	177.8±22.9	10.8±1.6
Overall		
SD	220.9±51.6	13.2±3.5
BF	224.2±56.4	13.4±3.8
MTV	226.2±54.9	13.7±3.5

4.5 Affective Responses

4.5.1 Feeling Scale

In-task affective valence, as measured by the FS, was analyzed using a 3 (condition: SD, BF, MTV) by 9 (time points: post-mask, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (RM-ANOVA). The findings for affective valence are presented graphically in Figure 5. The results showed significant main effects for both condition, $F(2, 56) = 12.461$, $p = .001$, $\eta^2 = .308$, and time, $F(1.445, 40.474) = 45.755$, $p = .001$, $\eta^2 = .620$, and a significant condition by time interaction, $F(6.056, 169.575) = 3.605$, $p = .002$, $\eta^2 = .114$.

Follow up Bonferroni-corrected pairwise comparisons at each time point revealed a significant decrease from Min 2 to 1 min pre-ventilatory threshold ($p = .017$), 1 min pre-ventilatory threshold to the ventilatory threshold ($p = .007$), a stabilization from the ventilatory threshold to 1 min post-ventilatory threshold, a significant decline from 1 min post-ventilatory threshold to 2 min post-ventilatory threshold ($p = .042$) that continued through to 1 min before the end of exercise testing ($p = .001$). The decline in affective responses approached significance between 1min before and the end of exercise testing ($p = .075$).

A series of separate analyses of variance by condition (3: SD, BF, MTV) at each time point revealed significant differences between the MTV condition and SD condition at Min 1 (3.03±1.05 vs. 2.48±1.21; $p = .039$), Min 2(2.93±1.03 vs. 2.38±1.15; $p = .021$), 1 min pre-ventilatory threshold (2.62±0.98 vs. 1.69±1.51; $p = .001$), at the ventilatory threshold (2.31±1.23 vs. 1.45±1.48; $p = .001$), 1 min post-ventilatory threshold (2.34±1.56 vs. 1.03±1.59; $p = .001$), and 2 min post-ventilatory threshold (1.97±1.66 vs. 0.79±1.72; $p =$

.001), 1 min before the end (0.34±2.13 vs. -0.45±2.28; *p* = .015), and the end of exercise testing (0.03±2.38 vs. -0.90±2.43; *p* = .003). Effect sizes confirm the meaningful differences at each time point (*ES*s = .48, .50, .72, .62, .89, and .69, respectively; all *p*s ≤ .05).The analyses also revealed differences between the MTV condition and BF condition starting at 1 min pre-ventilatory threshold (2.62±0.98 vs. 2.03±1.32; *p* = .021), at the ventilatory threshold (2.31±1.23 vs. 1.66±1.34; *p* = .005), 1 min post-ventilatory threshold (2.34±1.56 vs. 1.52±1.50; *p* = .017), 2 min post-ventilatory threshold (1.97±1.66 vs. 1.21±1.54; *p* = .03), 1 min before (0.34±2.13 vs. -0.38±1.93; *p* = .046), and the end of exercise testing (0.03±2.38 vs. -1.03±2.28; *p* = .012). Effect sizes confirm the meaningful differences at each time point (*ES*s = .50, .50, .53, .47, and .45, respectively; all *p*s ≤ .05), except 1 min before the end of exercise testing (*ES* = .35, *ns*).

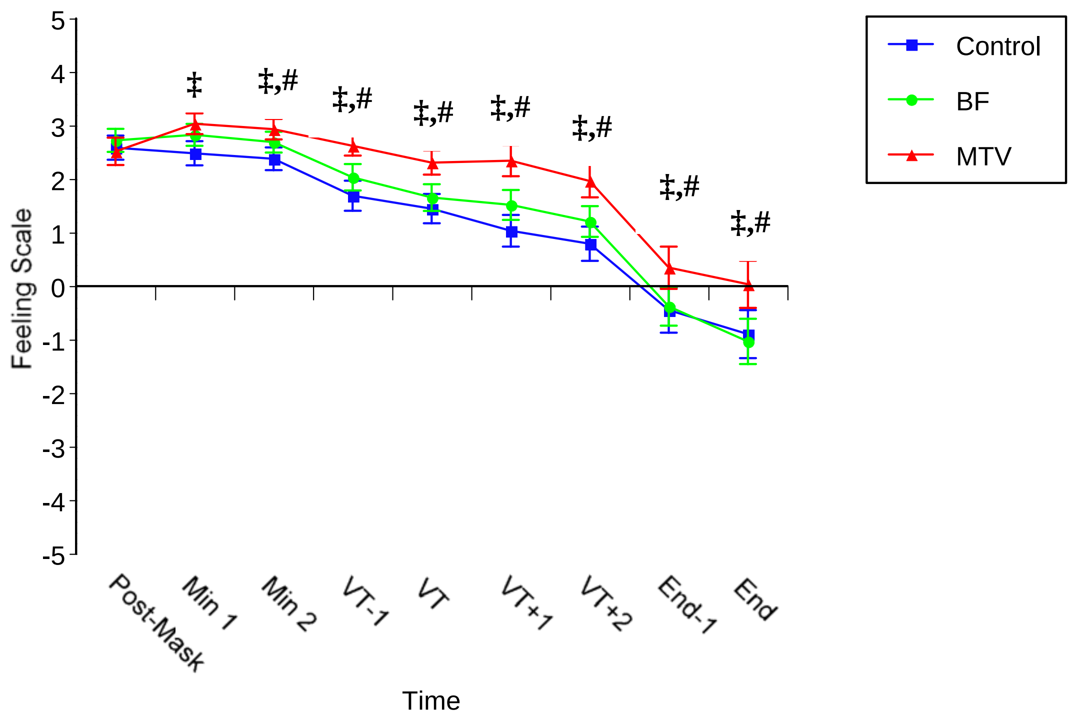
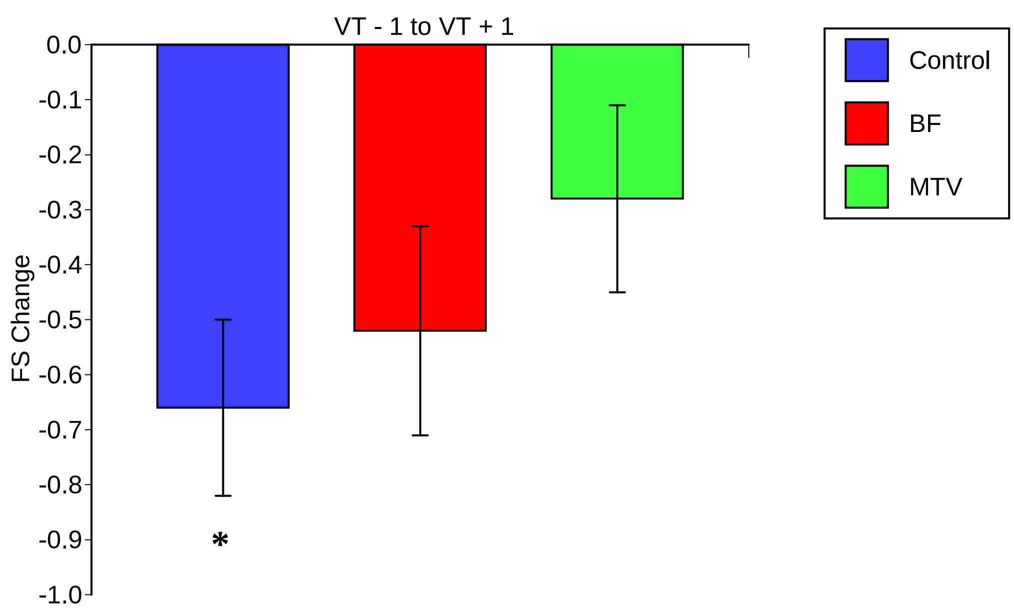


Figure 5. Line graph of ratings of pleasure-displeasure across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

The significant interaction result was followed up with separate RM-ANOVAs for each condition were used to analyze the changes over time in each condition followed by Bonferroni-corrected pairwise comparisons within each condition to isolate significant time-point to time-point changes. The results reveal that each condition significantly declined over time (all *p*s ≤ 0.05). There was a significant difference between the moment of and 1 min post-ventilatory threshold (p = .05) and from 2 min post-ventilatory threshold to 1 min before the end of exercise (p = .007) in the SD condition. There was a significant difference between Min 2 and 1 min pre-ventilatory threshold (p = .028) and from 2 min post-ventilatory threshold through 1 min before (p = .001) and the end of exercise (p = .011) in the BF condition. There was a significant difference between 1 min before and the moment of the ventilatory threshold (p = .05) and from 2 min post-ventilatory threshold to 1 min before the end of exercise (p = .001) in the MTV condition.



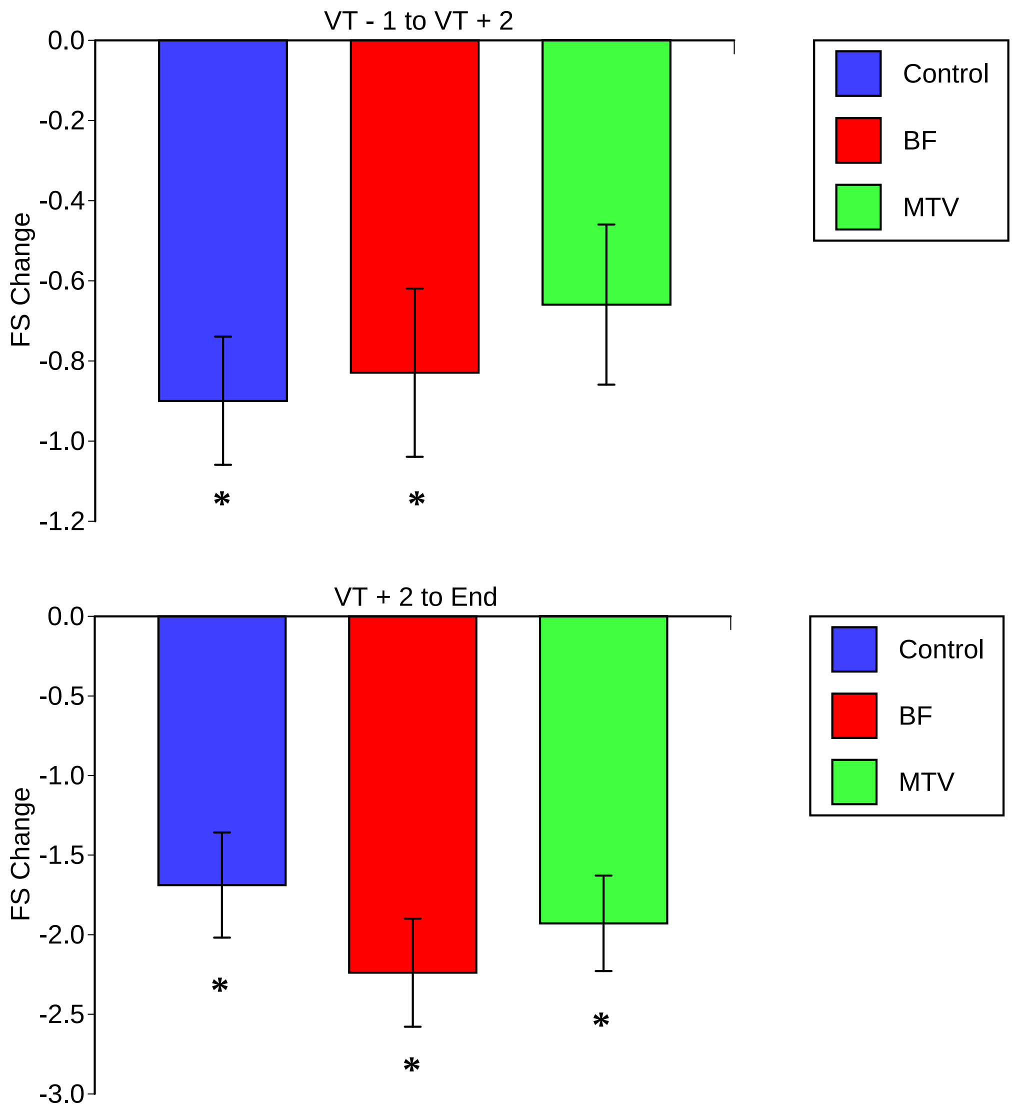


Figure 6. Bar graphs of changes in ratings of pleasure-displeasure across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise between VT – 1 and VT + 1 (top panel), VT – 1 and VT + 2 (middle panel), and VT + 2 to End of exercise (bottom panel). Significant differences within conditions ($p \leq 0.05$).

4.5.2 Felt Arousal Scale

A 3 (condition: SD, BF, MTV) by 9 (time points: Post-mask, Min 1, Min 2, pre-VT, VT, 1 Min post-VT, 2 Min post-VT, 1 Min before End, and End) repeated-measures analysis of variance (ANOVA) was conducted to examine for differences in perceived activation. The findings for perceived activation are presented in Figure 6. The results showed a non-significant main effect for condition, $F(2, 56) = 1.101$, $p = .339$, $\eta^2 = .038$, a significant main effect for time, $F(1.580, 44.251) = 22.405$, $p = .001$, $\eta^2 = .444$, and a significant condition by time interaction, $F(6.759, 189.242) = 2.630$, $p = .014$, $\eta^2 = .086$. Follow up Bonferroni-corrected pairwise comparisons at each time point revealed a significant increase from Min 2 to 1 min pre-ventilatory threshold ($p = .002$) and again from 2 min post-ventilatory threshold to 1 min before the end of exercise testing ($p = .055$). A series of separate analyses of variance by condition (3: SD, BF, MTV) revealed a significant difference between the MTV condition and C condition at Min 1 (3.66±1.17 vs. 3.12±0.96; $p = .026$) and Min 2 (3.78±1.03 vs. 3.12±.92; $p = .001$). Effect sizes confirm the meaningful difference at each time point (*ES*s = .50 and .67, respectively; *p*s < .05).

The significant interaction result was followed up with separate RM-ANOVAs for each condition were used to analyze the changes over time in each condition followed by Bonferroni-corrected pairwise comparisons within each condition to isolate significant time-point to time-point changes. The results reveal that each condition significantly increased over time (all *p*s ≤ 0.05). There was a significant difference between Min 2 and 1 min pre-ventilatory threshold ($p = .003$) in the SD condition. There was a significant difference between post-mask and Min 1 ($p = .045$) in the MTV condition.

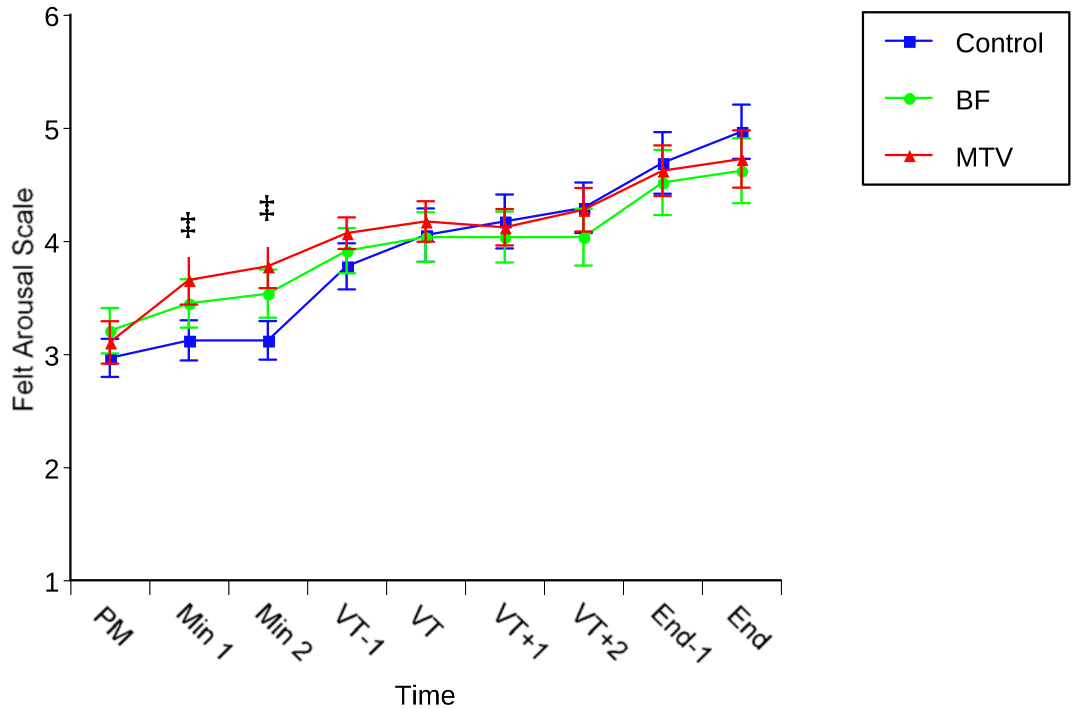


Figure 7. Line graph of perceived activation across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music.

4.6 Post-Exercise Results

4.6.1 Feeling Scale

Post-exercise affective valence (FS) was analyzed using a 3 (condition: SD, BF, MTV) by 5 (time: post-exercise [PE], post-cool down [PCD], and 10- [P10], 20- [P20], and 30-min [P30] post-exercise) repeated-measures analysis of variance (RM-ANOVA). The findings for post-exercise affective valence are presented graphically in Figure 7. The results show a non-significant main effect for condition, $F(2, 56) = 2.333$, $p = .106$, $\eta^2 = .077$. However, a significant main effect for time, $F(1.379, 38.606) = 47.779$, $p = .001$, $\eta^2 = .631$, and a significant condition by time interaction $F(4.508, 126.229) = 4.293$, $p = .002$, $\eta^2 = .133$ were revealed. Bonferroni-corrected pairwise comparisons for each time point across conditions revealed a significant increase in FS ratings immediately post-exercise up through 10-min post-exercise, stabilization between 10- and 20-min post-exercise, and finally another significant increase from 20- to 30-min post-exercise. A separate analysis of variance (ANOVA) by condition (3: SD, BF, MTV) at each time point revealed significant differences between the MTV condition and the SD condition immediately post-exercise (0.24±2.34 vs. -0.55±2.56), post-cool down (2.41±1.68 vs. 1.52±1.94), and a significant difference between the MTV condition and BF condition only at the 10-min mark of the 30-min recovery period (3.03±1.24 vs. 2.45±1.30; all *p*s < .05).

The significant interaction result was followed up with separate RM-ANOVAs for each condition were used to analyze the changes over time in each condition followed by Bonferroni-corrected pairwise comparisons within each condition to isolate significant time-point to time-point changes. The results reveal that each condition significantly increased over time (all ps ≤ 0.05). There was a significant increase from post-exercise to post-cool down ($p = .001$), post-cool down to min 10 ($p = .001$) of the recovery period in the SD condition. There was a significant increase from post-exercise to post-cool down ($p = .001$) and again from Min 10 to Min 20 ($p = .024$) of the recovery period in the BF condition. There was a significant increase from post-exercise to post-cool down ($p = .012$) in the MTV condition.

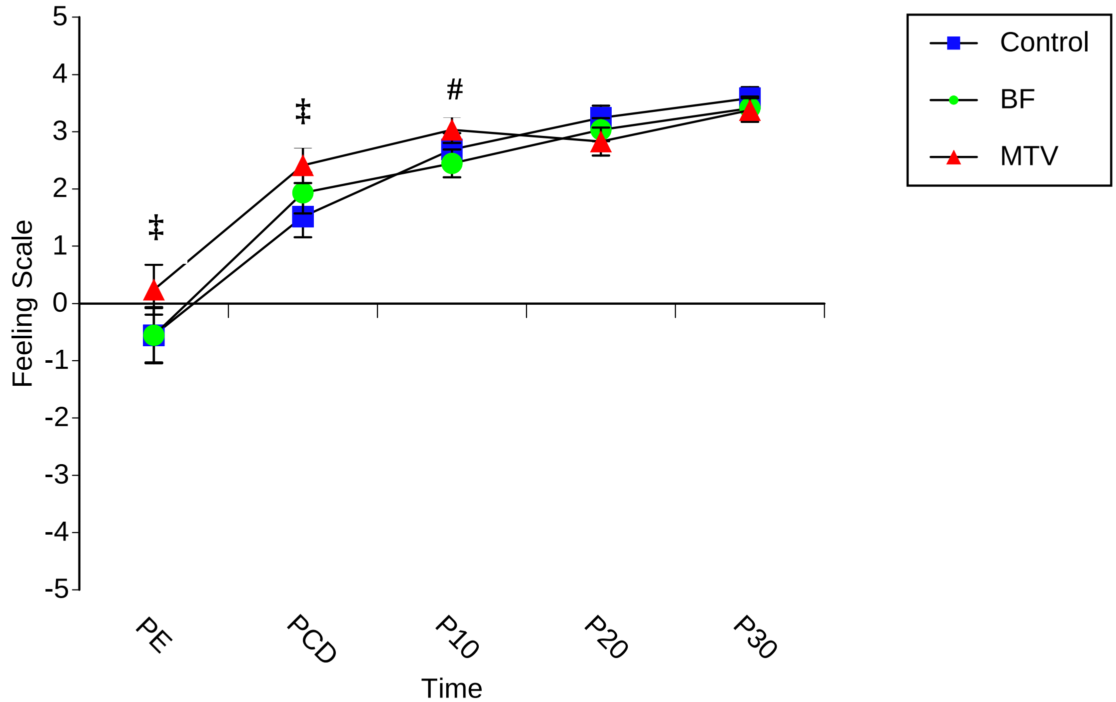


Figure 8. Line graph of post-exercise affective valence across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time main effect ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

4.6.2 Felt Arousal Scale

Post-exercise perceived activation (FAS) were analyzed using a 3 (condition: SD, BF, MTV) by 5 (time: post-exercise [PE], post-cool down [PCD], and 10- [P10], 20- [P20], and 30-min [P30] post-exercise) repeated-measures analysis of variance (RM-ANOVA). The results show a non-significant main effect for condition, $F(2, 56) = 1.017$, $p = .368$, $\eta^2 = .035$, and a non-significant condition by time interaction, $F(5.292, 148.169) = .405$, $p = .854$, $\eta^2 = .025$. However, a significant main effect for time, $F(1.407, 39.391) = 47.478$, $p = .001$, $\eta^2 = .629$, was found. Follow up Bonferroni-corrected pairwise comparisons across time points indicated a significant decrease in perceived activation starting post-exercise and continuing throughout cool down and 30 min of recovery (all *ps* < .005).

<u>*4.6.3 Physical Activity Enjoyment Scale (PACES)*</u>

Post-exercise perceived enjoyment of the exercise bout was analyzed using an analysis of variance (ANOVA) by condition (3: SD, BF, MTV). The findings for post-exercise perceived enjoyment are presented graphically in Figure 8. The results showed a significant difference between conditions, $F(2, 54) = 5.136$, $p = .009$, $\eta^2 = .160$. Follow up Bonferroni-corrected pairwise comparisons revealed that perceived enjoyment was significantly greater in the MTV condition (99.71±13.01) compared to either the SD (92.07±15.93; $p = .022$) or the BF (90.25±20.15; $p = .03$) experimental conditions. The results suggest that participants perceived greater enjoyment performing an incremental exercise test under an auditory-visual attentional dissociative condition compared to either a control condition or an auditory-visual attentional associative condition.

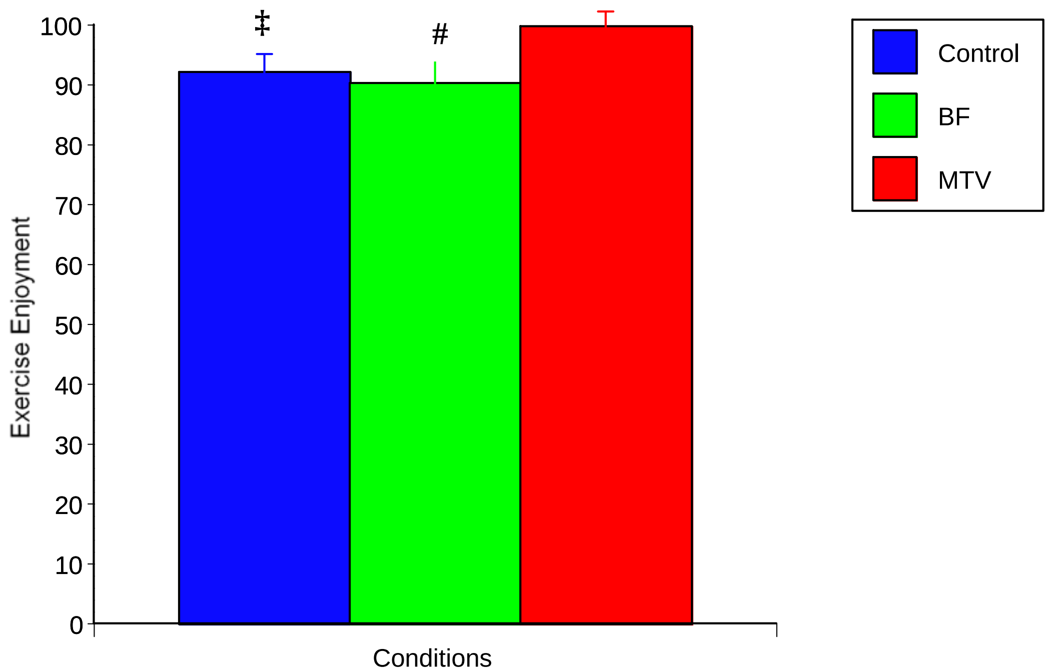


Figure 9. Bar graph of exercise enjoyment across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television. Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

CHAPTER 5. SUMMARY AND DISCUSSION

There appears to be accumulating evidence for the triadic relationship between exercise intensity, affective responses, and adherence to an exercise program. Briefly, research appears to support a causal chain in which higher exercise intensities are associated with declining affective responses (Acevedo, Kraemer, Haltom, & Tryniecki, 2003; Bixby, Spalding, & Hatfield, 2001; Ekkekakis, Hall, & Petruzzello, 2004; Hall, Ekkekakis, & Petruzzello, 2002) and decreasing exercise program retention (Cox, Burke, Gorely, Beilin, & Puddey, 2003; Epstein, Koeske, & Wing, 1984; Lee et al., 1996; Perri, et al., 2002; Sallis et al., 1986). In response to these proposed relationships, this investigation examined directly the primary relationship between exercise intensity and affective responses, and indirectly the secondary relationship between affective responses and exercise adherence. This was done utilizing a theoretical framework upon which specific research hypotheses could be advanced. This model, the Dual Mode Model (DMM), sheds light on the triumvirate factors proposed by highlighting, first and foremost, the critical nature of exercise intensity on affective responses and the related proposed outcome of poor exercise adherence that stems from high exercise intensities and feelings of displeasure, and by proposing the relative influence of cognitive strategies across different intensities of exercise.

The existing literature on the broader research area of attentional association and attentional dissociation as well as specific studies of associative and dissociative strategies of biofeedback and audio-visual stimuli (e.g., listening to music, watching television), respectively, have been characterized by a lack of theory-driven research (Masters & Ogles, 1998; Simpson & Karageorghis, 2006; Karageorghis & Terry, 1997; Priest, Karageorghis, & Terry, 2004). In response to these observations and in light of the paucity of conceptually based research, this investigation attempted to fill the void in the cognitive strategy-affective response literature by incorporating a psychophysiological model to predict responses across the continuum of pleasure-displeasure during a bout of exhaustive recumbent cycling exercise. In addition to this important theoretical advancement, the study also may clarify the efficacy of utilizing commonly employed cognitive strategies during an exercise bout.

Using the Dual Mode Model (Ekkekakis, 2003) as the underlying theoretical basis for the study, the investigation tested the model's basic tenets. Specifically, and in accordance with the model, it was hypothesized that (a) affective valence responses would be positive at low and moderate exercise intensities, but initiate a trend towards more negative/less positive responses as exercise intensities exceeded the ventilatory threshold through the conclusion of the exercise bout, (b), an attentional associative strategy (BF) would result in less positive/more negative affective responses approximate to the ventilatory threshold compared to an attentional dissociative strategy (MTV) and a sensory deprivation (SD) condition, while conversely, an attentional dissociative strategy would delay the onset of more negative/less positive affective responses approximate to the ventilatory threshold compared to an attentional associative strategy and a sensory deprivation condition, and (c) an attentional dissociative strategy would result in a more positive affective experience post-exercise (i.e. be rated as more enjoyable) compared to an attentional associate strategy or a sensory deprivation condition.

With respect to the first hypothesis, the findings generally confirmed the predicted relationship between affective responses and exercise intensity. Participants reported a general stabilization of positive affective responses from the onset of exercise up to 1 min before the ventilatory threshold (VT). Between this time point through min 2 following the

VT, there was a more gradual decline in affective responding, albeit the responses remained positive. The greatest acceleration of less positive/more negative affective responses occurred from 2 min following the VT through the end of exercise testing. Interestingly, contrary to the DMM, participants in the MTV condition, on average, rated the end of an exhaustive exercise bout as neutral (i.e. expressing feelings of neither good nor bad) whereas both the SD and BF conditions were rated negatively during the last 2 min of the bout.

With respect to the second hypothesis, the findings generally confirmed the predicted relationship between affective responses and exercise intensity. The (MTV) condition did show a delay in the onset of less positive/more negative affective responses compared to either the BF or the SD condition (Figures 5 and 6). However, the BF condition did not show the least positive/most negative affective responses approximate to the VT. Rather, the SD condition exhibited the lowest affective scores of the three experimental conditions. This was surprising given that the BF condition showed the highest degree of associative thought content throughout the exercise bout. In other words, it might be expected that a greater awareness of the effort being put forth during exhaustive exercise would translate into more negative affective responses.

With respect to the third hypothesis, the findings generally confirmed the predicted relationships between post-exercise perceived exercise enjoyment and affective responses. Participants reported higher perceived enjoyment scores in the MTV condition compared to both the BF and SD conditions (Figure X). Likewise, participants reported more positive affective responses after the MTV condition immediately post-exercise and following a 5 min cool down period compared to the SD condition, and at the 10 min mark of a 30 min recovery period compared to the BF condition. Throughout the final 20 mins of the recovery period, however, these differences in affective valence disappeared.

While the results provide partial support for the DMM, the theoretical contribution of the study to the exercise intensity-affective response literature can only be considered in relation to previous investigations. A number of researchers have observed a shift from primarily dissociative to primarily associative thought content as intensity levels of exercise increase (Hutchinson & Tenenbaum, 2007; Welch et al., 2007). Tenenbaum and Connolly (2008) noted that self-reported A/D strategies were predominantly dissociative at low exercise intensities (30% maximum rowing power), a combination of associative-dissociative thought content at moderate exercise intensities (50% maximum rowing power), and predominantly associative at higher exercise intensities (75% maximum rowing power). Related to this are the observations that the more associative the thought content of a participant becomes in relation to increasing physical demands, so to do self-reports of negative physical symptoms (Fillingim & Fine, 1986; Pennebaker & Lightner, 1980; Tenenbaum et al., 2004). In the current study, the 3 unit difference in attentional focus at min 2 of the exercise bout between the MTV and BF conditions was reduced to a 1.4 unit difference by the end. This result contributed to the rapid decline in affect once the VT had been exceeded. This suggests that, although the MTV and BF conditions induced a more dissociative and associative thought content, respectively, by the end of the exercise bout participants were more aware of interoceptive cues generated due to the increased effort.

It is not surprising that as exercise intensity increases that a shift towards more associative thought content occurs, resulting in greater awareness of the body’s signals to increasing effort. Similarly, a number of previous reports have examined the influence on affective responses under different attentional focus conditions. Welch et al. (2007) noted a systematic decline in affective valence past the ventilatory threshold along with increasing reports of associative thought content during an incremental exercise test. Fillingim and Fine (1986) reported better mood when performing a self-selected run while dissociating compared to an associative condition and a control condition. Perhaps most compelling are the results from a study by Boutcher and Trenske (1990). In their investigation, affective valence was similar across a self-selected music condition, sensory deprivation condition, and control condition while cycling at 60% HR_{max}. However, once the intensity increased to 75% and 85% HR_{max}, differences in affective valence emerged between conditions. Specifically, exercising to self-selected music resulted in more positive affective responses compared to sensory deprivation at both intensity levels and to a control condition at 75% HR_{max}. These findings prompted the researchers to conclude a “load-dependent” relationship between affective responses and exercise intensity, a central tenet to the current investigation.

Just as important as in-task affective responses is how participants rate the exercise bout once it has been completed. Kendzierski & DeCarlo (1991), as part of the development of the Physical Activity Enjoyment Scale (PACES), reported that participants rated a 20-min bout of submaximal cycling exercise with self-selected music as more enjoyable compared to a no music condition. Wininger and Pargman (2003) determined that 21% of the variance in exercise enjoyment, as measured by the PACES, could be explained by the music played during exercise. More recently, Russell and Newton (2008) noted greater affective valence 10 min following an interactive video cycle ergometry game performed at 60% to 70% HR_{max} compared to the video game alone. Compared to these past investigations, however, the current study distinguishes itself by utilizing a psychophysiological model with which to examine the influence of attentional focus strategies on affective responses. By utilizing the DMM, predictions of affective responses could be hypothesized in the present investigation whereas this was not the case in earlier studies.

The DMM provides important theoretical considerations that past theories or models did not and elucidates practical considerations for fitness practitioners that are immediately relevant. In particular, the model emphasized the critical nature of exercise intensity on affective responses, and specifically identified a physiological landmark, the ventilatory threshold, around which a shift from positive to more negative affective valence responses occurs. Thus, specific predictions related to how individuals will respond in affective terms can be made in relation to the ventilatory threshold. Moreover, the model also describes the relative saliency of various cognitive strategies thought to influence ratings of pleasure-displeasure. Applied to the real world, findings from this and future studies of the DMM may help fitness professionals in working with clients. The current findings question the common practice of using cognitive strategies with sedentary individuals either beginning or resuming an exercise program to override signals that originate internally and may have adaptive value (i.e. result in the individual stopping exercise before causing injury or serious harm). These advances over past models or theories underscore the potential of the DMM in shedding light on the exercise intensity – affective valence – exercise adherence chain.

While this investigation represents an important theoretical contribution to the cognitive strategy-exercise experience literature, there remain a number of interesting avenues for future research directions. Consistent with the findings of other reviews (Lind et al. in press), additional research is needed with more diverse samples of participants (i.e. older, more sedentary, different ethnicities). Likewise, this study utilized two popular cognitive strategies, namely biofeedback, in the form of breathing and heart rate feedback, and distraction, in the form of audio-visual stimuli. Future research should examine comparable cognitive strategies such as manipulations to an individual's self-efficacy, thematic and temporal analysis of self-talk, and the study of deception (i.e. knowledge of results) across incremental bouts of exercise to see if the current findings can be replicated. Imperative to these recommendations for future research is the need to base forthcoming studies on a conceptually sound theoretical foundation. The results of this study seem to suggest that the DMM may serve as a springboard for replication of the current study using different cognitive strategies with more diverse samples.

An additional avenue for future research is to examine the possible mechanisms that may underlie the current and any future findings. An emerging area of interest is to study real-time activity within selected cortical areas using non-invasive measures. One such measure, near-infrared spectroscopy (NIRS), has shown to have a number of advantages over other similar types of brain imaging techniques. For example, NIRS assessment is resistant to "noise" movement artifact (as compared to electroencephalography [EEG]), does not require the injection of radioactive tracers (as compared to single-photon-emission computed tomography [SPECT] and positron-emission tomography [PET]), and more affordable (as compared to functional magnetic resonance imaging [fMRI]). There is accumulating evidence beginning to emerge from NIRS studies of prefrontal cortex (PFC) oxygenation changes during incremental exercise that seems to suggest an increase in concentration levels during moderate intensity exercise and subsequent decrease as the individual approaches volitional exhaustion (Golzález-Alonso et al., 2004; Neilsen, Boushel, Madsen, and Secher, 1999; Neilsen et al., 2001). Relative to the current study, it could be argued that increases in

PFC oxygen concentrations at low and moderate exercise intensities suggest an increased potential effectiveness of cognitive intervention strategies while a decrease towards the end of the exercise bout would indicate that the potential of cognitive mechanisms to influence affective responses may be diminished.

It is important to consider the findings of the current study in light of certain possible limitations. First, participants exercised in a contrived laboratory environment enclosed by a black shroud and were adorned with various testing equipment. Given the nature of the research questions, however, it was deemed necessary to sacrifice some degree of external validity in order to better address the hypotheses. Second, the sample of the study was college-aged (overall average age: 22.7±3.6 yr), moderately active, of similar socioeconomic status, and ethnically homogenous (94% Caucasian). Third, the exercise modality used for the study may have contributed to the results. Recumbent cycling ergometry may have resulted in participants not reaching true physiological exhaustion due to the non-weight-bearing nature of the equipment, and this, in turn, may have impacted the affective responses. Thus, the findings can only be generalized to participants with similar characteristics utilizing a similar exercise mode under similar testing conditions. These observations, collectively, justify the need for future research with more diverse samples exercising under different exercise modalities. It should also be noted that the sensory deprivation condition was treated as a control condition. However, as evidence in some of the findings, this condition, and not the BF condition, as hypothesized, was the lower of the experimental conditions. In other words, the nature of the SD condition may, itself, have been a different form of attentional association and resulted in some of the unexpected results (e.g., Figure 5). Likewise, the scores on the PACES across all conditions were high compared to the measure's maximum score of 126. Thus, while there was a significant difference between conditions, both the SD and BF conditions were still perceived to be relatively enjoyable in relation to the MTV condition. Finally, it is interesting to note that while the MTV condition resulted in improved affective responses compared to both the BF and SD conditions, not all participants preferred an attentional dissociative strategy. In particular, 10% of participants reported preferring the attentional association strategy. While these limitations are important to consider and should be taken into account in future research endeavors, they do not detract from the primary findings that (a) ratings of pleasure were delayed , under a certain attentional dissociative condition, in the initiation of a decline from positively toward negatively valence responses around the ventilatory threshold through the conclusion of an exhaustive exercise bout, and (b) an attentional dissociative strategy showed more positive affective responses and greater perceived exercise enjoyment post-exercise compared to the other experimental conditions.

In summary, exercising under an attentional dissociation condition, induced by watching a music DVD, produced more positive affective responses compared to either a sensory deprivation or an attentional association condition in the form of heart rate and ventilatory biofeedback, despite the fact that multiple measures of exercise intensity suggested participants were under similar physiological strain across conditions. Moreover, an attentional dissociation condition resulted in a delay of the onset of more negative affective responses compared to the other two experimental conditions. Contributing to these results was the fact that participants reported more dissociative thought content during the attentional dissociation condition than the other two experimental conditions. Moreover, post-exercise affect and perceived exercise enjoyment was higher following the attentional dissociative condition. These findings provide partial support for the Dual Mode Model as a viable theoretical foundation upon which future research can be conducted and a clear understanding of the relationship between exercise intensity, affective responses and exercise adherence can begin to be established.

APPENDIX A: INFORMED CONSENT FORM

INFORMED CONSENT DOCUMENT

Title of Study: Psychological and physiological responses to graded cycle ergometer exercise.

Investigators:
Panteleimon Ekkekakis, Ph.D.*
Associate Professor
235 Forker Building
Department of Kinesiology
Iowa State University
Ames, IA 50011-1160
Tel. (515) 294-8766
E-mail: ekkekaki@iastate.edu

Amy Welch, Ph.D.*
Assistant Professor
251 Forker Building
Department of Kinesiology
Iowa State University
Ames, IA 50011-1160
Tel. (515) 294-8042
E-mail: amywelch@iastate.edu

Erik Lind, M.S.**

*Co-Principal Investigators
** Research assistant who will conduct the study and obtain informed consent

This is a research study. Please take your time in deciding if you would like to participate. Please feel free to ask questions at any time.

INTRODUCTION

The purpose of this study is to examine physiological and psychological responses to graded cycle ergometry exercise. You are being invited to participate in this study because we are investigating specific physiological and psychological responses in a representative sample from a young, healthy adult (ages 18 to 35 years old) population.

DESCRIPTION OF PROCEDURES

If you agree to participate in this study, your participation will last for the duration of four separate visits to the exercise psychology laboratory (0164M Forker Building on the ISU campus). During the **first visit**, you will be familiarized with the instruments and equipment used in the data collection process while performing 5-10 minutes of cycle exercise at a moderate intensity level. Following this you will also be asked to complete a battery of questionnaires. During the **second, third** and **fourth visits** you will perform a graded (incremental) exercise test on a recumbent cycle ergometer. This is a test that determines the ability of your body to take oxygen from the air, deliver it to your working muscles and utilize the oxygen in the muscle. The pedal resistance of the cycle ergometer will be gradually increased until you choose to discontinue the test. You will be able to terminate the test yourself when you feel that you have reached your limit. This test is expected to last between 5 and 15 minutes in addition to warm-up and cool-down. Before the test, the researchers will secure detectors on your forehead (using a headband) to monitor the activity in the frontal cortex of your brain. They will also attach a breathing mask on your face, so that they can collect and analyze the gases that you expire and, thus, determine how much oxygen you are using. A heart rate monitor will be placed around your chest to monitor heart function during the test. There will be a 3-minute warm-up before the test and a 5-minute cool-down after the test. Upon completion of the test, you will rest comfortably for 30 minutes. During two of these visits you will be exposed to audio-visual stimuli. A video screen will be positioned in front of the recumbent cycle ergometer and stereo headphones will be provided to listen to the auditory content. During the other visit, you will wear sound-dampening headphones while performing the graded (incremental) cycle ergometer test. The order in which the second, third and fourth visits take place will be randomized.

During visits 2-4, the researchers will ask you to indicate how you feel on some simple ratings scales. **You may skip any question that you do not wish to answer or that makes you feel uncomfortable.** All the visits are expected to last approximately 60 to 90 minutes.

RISKS

Participating in vigorous exercise may carry potential dangers, such as cardiovascular problems or musculoskeletal injuries. Although it is not possible to predict all such occurrences, the researchers try to minimize the risk. Other possible adverse effects include: (a) Muscle soreness or fatigue during or following the exercise sessions. These effects should not last more than a couple of days. You have the right to request that another exercise session not be scheduled until these symptoms have passed, (b) Discomfort associated with wearing the face mask that will be used for the collection of expired gases. You will be able to try this mask on to see whether you feel comfortable wearing it. The researchers will assist you in adjusting the mask so that it is as comfortable as possible, but you have the right to withdraw your consent if you feel discomfort or resistance in your breathing, (c) An elastic athletic wrap is used to secure the detectors to the forehead. You may experience some discomfort from the wrapping around the forehead. Please note that all materials that you will come in contact with (including the face mask) will be either single-use or thoroughly washed and disinfected.

BENEFITS

If you decide to participate in this study there will be a direct benefit to you: you will receive a free fitness assessment and specific, personalized physical activity recommendations based on your fitness assessment. It is also hoped that the information gained in this study will benefit society by providing valuable information on the types and amounts of physical activity that are likely to increase people's motivation to remain active over the long haul.

COSTS AND COMPENSATION

You will not have any costs from participating in this study. However, you may receive monetary compensation, up to $50.00, for your involvement. The money will be distributed in the following manner: $10.00 for completion of trial 1; $10.00 for completion of trial 2; $10.00 for completion of trial 3; and $20.00 for completion of trial 4. In order to receive your honoraria, you must complete the Iowa State University Research Participant Receipt Form (RPRF).

PARTICIPANT RIGHTS

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. If you decide to not participate in the study or leave the study early, it will not result in any penalty or loss of benefits to which you are otherwise entitled.

RESEARCH INJURY

Emergency treatment of any injuries that may occur as a direct result of participation in this research is available at the Iowa State University Thomas B. Thielen Student Health Center, and/or referred to Mary Greeley Medical Center or another physician or medical facility at the location of the research activity. Compensation for any injuries will be paid if it is determined under the Iowa Tort Claims Act, Chapter 669 Iowa Code. Claims for compensation should be submitted on approved forms to the State Appeals Board and are available from the Iowa State University Office of Risk Management and Insurance.

CONFIDENTIALITY

Records identifying participants will be kept confidential to the extent permitted by applicable laws and regulations and will not be made publicly available. However, federal government regulatory agencies (the National Institutes of Health) and the Institutional Review Board (a committee that reviews and approves human subject research studies) may inspect and/or copy your records for quality assurance and data analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, your name and other identifying information will be permanently erased once the collected data have been tabulated and entered in a computer for statistical analysis. Thus, there will be no traceable connection between your name and your data. Until the data are tabulated, your records will be kept in a room that will be locked at all times and only the researchers will have access to it. If the results are published, your identity will remain confidential.

QUESTIONS OR PROBLEMS

You are encouraged to ask questions at any time during this study. For further information about the study, contact Dr. Amy Welch (251 Forker Building, 515-294-8042, amywelch@iastate.edu) or Dr. Panteleimon Ekkekakis (253 Forker Building, 515-294-8766, ekkekaki@iastate.edu). If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, Office of Research Assurances, (515) 294-3115, 1138 Pearson Hall, Ames, IA 50011.

****

PARTICIPANT SIGNATURE

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.

Participant's Name (printed) ____

______________________________________ ______________________

(Participant's Signature) (Date)

INVESTIGATOR STATEMENT

I certify that the participant has been given adequate time to read and learn about the study and all of their questions have been answered. It is my opinion that the participant understands the purpose, risks, benefits and the procedures that will be followed in this study and has voluntarily agreed to participate.

______________________________________ ______________________

(Signature of Person Obtaining Informed Consent) (Date)

APPENDIX B: DEMOGRAPHIC PROFILE

Demographic Information

Name: ______________________________ **Gender**: Male ☐ Female ☐

Age:_________ **Birthday**: ______/_______/_______ **Phone**: (515) -

E-mail address: ____

Are you a member of a National Collegiate Athletic Association (NCAA)-sanctioned team at Iowa State University?

Yes **No**

On average:

How many days a week do you spend in these activities?__________________

How much time each training session do you spend in these activities?____________
(minutes)

Please indicate on the scale below your preference for listening to music while you engage in physical activity.

I strongly prefer not to listen to music					**Neutral**			**I strongly prefer to listen to music**		
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

PAR- Q & YOU

Yes	**No**	
☐	☐	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for you blood pressure or heart condition?

☐ ☐ 7. Do you know of any other reason why you should not do physical activity?

Brief Past Medical History

☐ ☐ 8. Have you ever been diagnosed with a medical condition that currently is under control (e.g., high blood pressure)? If yes, describe____

☐ ☐ 9. Were you prescribed any medication for this past medical diagnosis? If yes, describe_______________________________

RISK FACTORS

1. Smoking

	Yes	**No**		
Do you smoke	☐	☐		
Cigarettes	☐	☐	How many per day? _____	How many years? ____
Cigar	☐	☐	How many per day? _____	How many years? ____
Pipe	☐	☐	How many times per day?__	How many years?_____

HAVE YOU HAD A RECENT MEDICAL CHECK-UP?

It was explained to me that participation in bouts of vigorous exercise might be harmful to people with certain medical conditions. I hereby confirm that I have had a physical examination within the last 12 months, which showed that I am in perfect health. I also confirm that, to the best of my knowledge, I have no history of any cardiovascular, respiratory, musculoskeletal, or mental conditions. Finally, at this time, I am not suffering from any injuries or other ailments and I am under no medication.

_________________________________ ______________________________

(**Signature**) (**Date**)

Stages of Change Questionnaire

	True	**False**
1. I currently do not exercise	☐	☐
2. I intend to exercise in the next 6 months	☐	☐
3. I currently exercise regularly*	☐	☐
4. I have exercised regularly* for the past 6 months	☐	☐
5. I have exercised regularly* in the past for at least 3 months, but I am not doing so current	☐	☐

7-Day Physical Activity Recall Interview Questionnaire

Now we would like to know about your physical activity during the past 7 days. And also let me ask you about your sleep habits.

1. On the average, how many hours did you sleep each night during the last **5** weekday nights (Sunday through Thursday)? (Record to the nearest quarter-hour)

   ☐☐ ☐ Hours

2. On the average, how many hours did you sleep each night **last Friday and Saturday** nights?

   ☐☐ ☐ Hours

3. Now about your physical activities, let's first consider **moderate** activities. What activities did you do and how many total hours did you spend during the last **5** weekdays doing these moderate activities or others like them? Please tell me to the nearest half-hour.

   ☐☐ ☐ Hours

4. **Last Saturday and Sunday**, how many hours did you spend on **moderate** activities and what did you do? (Probe: Can you think of any other sport, job, or household activities that would fit into this category?)

   ☐☐ ☐ Hours

5. Now let's look at **hard** activities. What activities did you do and how many total hours did you spend during the last **5** weekdays doing these hard activities or others like them? Please tell me to the nearest half-hour.

   ☐☐ ☐ Hours

6. **Last Saturday and Sunday**, how many hours did you spend on **hard** activities and what did you do? (Probe: Can you think of any other sport, job, or household activities that would fit into this category?)

   ☐☐ ☐ Hours

7. Now let's look at **very hard** activities. What activities did you do and how many total hours did you spend during the last **5** weekdays doing these hard activities or others like them? Please tell me to the nearest half-hour.

   ☐☐ ☐ Hours

8. **Last Saturday and Sunday**, how many hours did you spend on **very hard** activities and what did you do? (Probe: Can you think of any other sport, job, or household activities that would fit into this category?)

   ☐☐ ☐ Hours

Scheduling

Your first trial is scheduled for: ________/__________/____________

Trial 2: __________/____________/_____________

Trial 3: __________/____________/_____________

Reminders for participants:

1. Do **NOT** smoke, drink caffeinated beverages, exercise or eat a heavy meal for 2 hours before testing time.
2. Come in **comfortable** clothes/shoes to exercise in.
3. Bring reading **glasses** if you need them for the surveys.
4. As best as you can, please **refrain from listening to music** prior to your scheduled trial.

APPENDIX C: FEELING SCALE/FELT AROUSAL SCALE/RATING OF PERCEIVED EXERTION/ATTENTIONAL FOCUS SCALE

ISU IRB #1 07-458
Approved Date: 28 February 2008
Expiration Date: 9 October 2008
Initial by: jlc

Perceived Exertion

6	No exertion at all
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Very, very hard
20	Maximal exertion

Feeling Scale

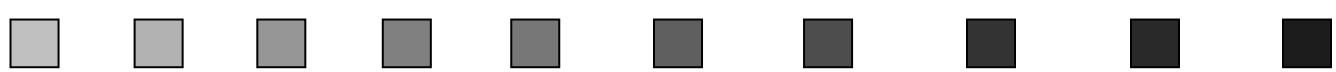
+5	Very Good
+4	
+3	Good
+2	
+1	Fairly Good
0	Neutral
-1	Fairly Bad
-2	
-3	Bad
-4	
-5	Very Bad

Felt Arousal Scale

6	High Arousal
5	
4	
3	
2	
1	Low Arousal

Thoughts

Associative (e.g., sweatiness, heavy breathing, pain).



Dissociative (e.g., external thoughts, day dreams).

APPENDIX D: PHYSICAL ACTIVITY ENJOYMENT SCALE

PACES			

INSTRUCTIONS: Please rate how you feel at the moment about the physical activity you have been doing.

1.	I enjoy it	①②③④⑤⑥⑦	I hate it
2.	I feel bored	①②③④⑤⑥⑦	I feel interested
3.	I dislike it	①②③④⑤⑥⑦	I like it
4.	I find it pleasurable	①②③④⑤⑥⑦	I find it unpleasurable
5.	I am very absorbed in this activity	①②③④⑤⑥⑦	I am not at all absorbed in this activity
6.	It's no fun at all	①②③④⑤⑥⑦	It's a lot of fun
7.	I find it energizing	①②③④⑤⑥⑦	I find it tiring
8.	It makes me depressed	①②③④⑤⑥⑦	It makes me happy
9.	It's very pleasant	①②③④⑤⑥⑦	It's very unpleasant
10.	I feel good physically while doing it	①②③④⑤⑥⑦	I feel bad physically while doing it
11.	It's very invigorating	①②③④⑤⑥⑦	It's not at all invigorating
12.	I am frustrated by it	①②③④⑤⑥⑦	I am not at all frustrated by it
13.	It's very gratifying	①②③④⑤⑥⑦	It's not at all gratifying
14.	It's very exhilarating	①②③④⑤⑥⑦	It's not at all exhilarating
15.	It's not at all stimulating	①②③④⑤⑥⑦	It's very stimulating
16.	It gives me a strong sense of accomplishment	①②③④⑤⑥⑦	It does not give me any sense of accomplishment
17.	It's very refreshing	①②③④⑤⑥⑦	It's not at all refreshing
18.	I felt as though I would rather be doing something else	①②③④⑤⑥⑦	I felt as though there was nothing else I would rather be doing

APPENDIX E: ATTENTIONAL ASSOCIATION AND DISSOCIATION TABLE

Ia. Investigations of Attentional Association and Dissociation during submaximal exercise.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Acevedo et al.[58]	•N = 112 (86 M / 26 W) •Average age: 40.2 y	•Trained •Ultraendurance athletes	Submaximal	100 miles	Running	Self-reported A/D strategy	•SOQ •TSCI •CRS			•No difference in cognitive strategies between athletes or gender (50.4% dissociate, 49.6% associate) •Open-ended questions on cognitive strategy resulted in 75% of responses being classified as external (dissociation)
Bachman et al.[55]	•N = 33 (13 M / 20 W) •College-aged	•Trained •Cross-country runners	Submaximal [competitive pace]	Varied, up to 7 miles	Running	A/D strategy during: •Easy training run (ETR) •Interval workout (INT) •Competitive race (CR)	•TDRS •State Competitiveness question			•CR and INT = higher associative subscale scores compared to ETR •ETR = higher Daily Events and External Surroundings subscales scores compared to INT and CR •State competitiveness significantly correlated with Associative ($r = .59$), Daily Event ($r = -.40$), and Interpersonal Relationships ($r = -.38$) subscales
Baden et al.[90]	•N = 16 (8 M / 8 W) •Average age: 30.4±4.1 y	•Moderately trained •Average VO_2peak: 56.4±2.9 ml·kg·min^{-1}	75% Peak Treadmill Speed	20-min total	Treadmill run	•20 min (20 MIN) •10 min + 10 more min (10 MIN) •20 min (UN)	•RPE •Affect •%A/D strategy	•VO_2 •HR	•Stride Frequency	•RPE increased significantly between mins 10 and 11 of 10 MIN condition compared to 20 MIN and UN conditions •Affect decreased significantly from mins 10 and 11 of 10 MIN compared to 20 MIN condition •VO_2 lower from mins 10 to 19 in UN compared to 20 MIN condition •Increase in percentage of associative thoughts in each condition as exercised progressed •No difference in HR or stride frequency
Baghurst et al.[122]	•N = 14 (12 M / 2 W) •Average age: 22.5 y	•Healthy •Sports science students	Level 4 resistance	15-min	Rowing	•Association (Internal/External) vs. •Dissociation (Internal/External)			•Distance rowed	•Internalisers performed better w/ Association •Externalisers performed better w/ Dissociation •Externalizers in Dissociative condition performed better overall •Internalizers in Associative compared to Dissociative condition and Externalizers in Dissociative compared to Associative condition rowed further at mins 10 and 15 •Participants reported difficulty in adhering to non-preferred A/D strategy as test progressed
Baker et al.[78]	N = 21 •Expert = 8 •Mid-pack = 7 •Back-of-the-pack = 6	•Trained •Competitive triathletes	Retrospective recall using video competition montage			Self-reported A/D strategy as: •Passive (dissociation) •Active (association) •Proactive (association)	•Recall of A/D strategy during competition			•Expert triathletes recalled more active-performance related thoughts at each point of video montage •Other groups showed more variability across different thought classifications •Experts used more associative-type thoughts during phases in which passing/being passed •Back of the pack used both associative and dissociative type thoughts with equal frequency
Blanchard et al.[110]	•N = 69 W Average age: •25-min group (n = 25): 21.54±5.65 y •40-min group (n = 24): 25.55±4.47 y •Control group (n = 20): [illegible]	•Trained Average training workload: •25-min group: 18.67±12.36 km/run •40-min group: 12.72±4.20 km/run •Control group: 19.91±10.55 km/run	70% HRR	•25-min •40-min	Running	Random assignment to: •Running group •Control group	•EFI •RPE •Self-reported A/D strategy			•More dissociative-external thoughts in each running condition associated with greater changes in a) Revitalization and b) lower Physical Exhaustion pre- to post-exercise scores •Trend for increased Positive Engagement; no change in Tranquility
Brewer et al.[82]	•N = 44 •College-aged	•Trained cross-country runners (n = 9) •Healthy students (n = 35)	Level 9 resistance	12-min	Stair-climbing		•RPE •FS •AFQ •Self-reported Pain		•Feet climbed	•Stairclimbing performance negatively correlated with pre-exercise dissociation and pre-exercise distress, and positively correlated with post-exercise association scores •Post-exercise distress positively correlated with RPE and self-reported pain, and negatively correlated with FS •Cross-country runners reported more associative/less dissociative thoughts compared to non-trained participants •Females reported significantly higher pre-exercise distress and post-exercise distress and dissociative scores compared to males •Cross-country runners and males climbed more feet than untrained and female participants

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Cioffi[108]	•N = 56 M •Average age: 19.1 y	Healthy	60% VO_2max	10-min	Bike	Internal attentional focus vs. control with affective manipulation in each group (threat of shock)	•Emotional Distress •Self-report of Sensations •Thought Prominence			•Participants instructed to attend internally reported more thoughts about physical sensations compared to control group •Instructions to monitor physical sensations did not result in greater number of discrete physical symptoms reported or greater noticeability of symptoms •Participants instructed to attend internally reported more positive affect under no threat of shock and more negative affect under threat of shock
Clingman & Hilliard[135]	•N = 16 (8 M / 8 W) •Age range: 33-76 y	•Trained •Competitive race walkers	Submaximal [5K pace]	Repeated 800 m	Race walking	•Internal focus (cadence) •Internal focus (stride length) •External focus			•Walk time	•Internal focus (cadence) better than internal focus (stride length) and external focus
Connolly & Janelle[83] Study 1	•N = 9 W •Average age: 19.9±1.31 y	•Trained •Experienced rowers	Submaximal ("steady-state" or 75% pressure)	20-min	Rowing	•Association (breathing/bodily symptoms) •Dissociation (collages)	•RPE	•HR	•Distance rowed	•Association led to significant increase in meters rowed, but had no effect on either RPE or HR responses
Connolly & Janelle[83] Study 2	•N = 22 (10 M / 21 W) Average age: •M: 19.6±1.96 y •W: 20.3±1.97 y	•Trained •Experienced rowers	HR between 160-180 bpm (characterized as "anaerobic pressure")	2000 m	Rowing	•Internal Association (i.e. bodily sensations) •External Association (i.e. rowing imagery) •Internal Dissociation (i.e. mental arithmetic) •External Dissociation (i.e. watch videotape)	•RPE •AFQ	•HR		•Internal/External Associative condition produced improved performance over baseline values •No difference compared to baseline values in internal/external dissociative conditions •Internal/external associative conditions resulted in faster rowing times compared to only internal dissociative condition •Higher HR in internal/external associative conditions compared to baseline condition •External associative condition produced higher HR compared to internal associative condition, but not external dissociative condition •Higher RPE in internal/external associative condition compared to baseline •Associative condition produced overall faster rowing time compared to dissociative condition
Couture et al.[104]	•N = 40 M •Average age: 23.9 y	•Trained •Canadian Infantry	Military pace w/ standardized gear	16 km (3 hours)	Marching	•Biofeedback (i.e. association) •Meditation (i.e. dissociation) •Combination (biofeedback + meditation) •Control	•RPE •SACT •Perception of Time Remaining	•EMG •HR •PHT		At end of 1st march: •18/50 soldiers used associative thinking; •22/50 used dissociative thinking •Soldiers using association better at predicting remaining marching time •No difference in RPE or HR across experimental conditions •Control group = less perceived fatigue, lower RPE, and lower HR between 1st and 2nd march
Delignières & Brisswalter[94]	•N = 8 (4 M / 4 W) •Average age: 17.8±0.7 y	Average VO_2max: •Males = 60.2±3.9 $ml\cdot kg\cdot min^{-1}$ •Women = 42.2±3.9 $ml\cdot kg\cdot min^{-1}$	•20% •40% •60% •80% VO_2max	Four 4-min stages	Bike	•Effort Alone •Effort + Reaction Time task	•RPE	•HR		•HR and RPE both higher in the Effort + Reaction Time task at each intensity level compared to Effort Alone condition
Donohue et al.[132]	•N = 6 W •Age range: 18-21 y	•Trained •Cross-country runners	Submaximal	1 km run	Running	•Motivational statements •Optimum performance statements •Thought Content questions			•Run time	•Each experimental group improved running performance over baseline time •Optimum performance run statements (i.e. association) showed greatest improvement, followed by Motivational statements and Thought content questions
Durtschi & Weiss[49]	•N = 66 Elite group: n = 18 (11 M / 7 W) Non-elite group: n = 48 (27 M / 21 W)	•Trained •Competitive marathoners	Submaximal	42.5 km	Running	Questionnaire responses	•SCAT •CSAI •POMS		•Run time •Finishing place	•Elite participants reported greater psychological strength to endure (long distance races) compared to non-elites •Non-elites reported more dissociative thoughts •Elites performance times closer to predicted pace and finishing times compared to non-elites •Thought themes of elites: "monitor body signals", "focus on breathing and pace" •Thought themes of non-elites: "push through feelings of pain", "creative thoughts"
Fillingim et al.[76]	•N = 60 W •College-age	•Sedentary •Average estimated VO_2max: 33.0±8.5 $ml\cdot kg\cdot min^{-1}$	Submaximal	10 min	Bike	•High demand distraction •Low demand distraction •No distraction	•POMS •RPE •Physical symptoms post-exercise		•Exercise duration	•Distraction conditions had no effect on mood scores, exercise performance, or post-exercise physical symptom reports

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Freischlag[60]	•N = 55 (52 M / 3 W) •Average age: 43 y	•Trained •Marathon runners •Average marathon time: 3:23	Submaximal [competitive pace]	42.5 km	Running	Retrospective recall	•A/D strategy prevalence			During marathon: •30% used dissociation •76% used association
Goode & Roth[79]	•N = 150 (103 M / 47 W) •Average age: 31.7 y	Healthy	Submaximal	Normal training run duration	Running	Scale development	•TDRS •POMS			•Fatigue positively correlated with Association and negatively correlated with Dissociative categories (Interpersonal Relationships, Daily Events) •Vigor positively associated with Dissociative categories (Interpersonal Relationships, Daily Events, External Surroundings)
Goudas et al.[136]	•N = 75 W •Average age: 20.1	•Healthy •Physical Education students	Submaximal	Varied	Bike	Goal-setting groups: •Lower HR •Lower HR + Performance Improvement •Performance Improvement •Control Group		•HR	•Time to reach 170 bpm	•Lower HR group significantly increased time to reach 170 bpm compared to other groups •All groups increased performance time, however, only Lower HR and Control groups decreased average HR compared to other two groups
Harte & Eifert[101]	•N = 10 M •Average age: 27.1 y	•Trained •Amateur marathon runners and triathletes	Submaximal	45-min	Running	•Outdoor run (dissociation) •Indoor run (external stimuli) •Indoor run (internal stimuli) •Control	•RPE •POMS •Self-report affect	•Epi •Norepi •Cortisol		•Outdoor run = less anxious, less depressed, less angry, less fatigued, more vigor compared to pre-test •Indoor run with internal focus = more tense, more depressed, more angry, more fatigued compared to pre-test •Indoor run with internal focus = higher RPE compared to outdoor run and indoor run with external focus •Greater percentage of dissociation during outdoor run •Greater percentage of association during indoor run with internal focus •Norepi and cortisol significantly higher after indoor run with internal focus compared to outdoor run
Hassmén & Koivula[88]	•N = 50 W •Average age: 25.7±4.4 y	•Moderately trained •Psychology students •Est. VO_2max: 42.0±6.5 $ml \cdot kg \cdot min^{-1}$	Submaximal	Four 4-min stages	Bike	•External LoC (Ext) •Internal LoC (Int)	•RPE	•HR		•External Locus of Control participants had higher RPE at a HR of 150 bpm •Internal Locus of Control participants had higher HR at a RPE of 15
Hatfield et al.[126]	•N = 12 M •Average age: 22.0±1.3 y	•Trained •Average VO_2max: 65.8±1.2 $ml \cdot kg \cdot min^{-1}$	Sub-VT	36-min	Treadmill run	•Association (biofeedback) •Dissociation (reaction time test) •Control Condition	•RPE	•VO_2 •VCO_2 •RR •V_E •TV •V_E/VO_2 •V_E/VCO_2 •$PETO_2$ •$PETCO_2$ •HR •RQ •O_2 pulse		•No difference in VO_2, VCO_2, HR, RQ, and O_2 pulse across conditions •V_E, RR, V_E/VO_2, V_E/VCO_2 reduced during Biofeedback condition compared to Distraction and Control conditions •TV and $PETCO_2$ increased during Biofeedback condition compared to Distraction and Control conditions •RPE lower during Biofeedback and Distraction conditions compared to Control condition
Hutchinson & Tenenbaum[143] Study 2	•N = 13 (7 M / 6 W) •Average age: 26.85±4.91 y	•Moderately trained Average VO_2max •Men: 48.1±10.83 $ml \cdot kg \cdot min^{-1}$ •Women: 41.7±6.75 $ml \cdot kg \cdot min^{-1}$	•50% •70% •90% VO_2max	•50% and 70% VO_2max = 5 min; •90% VO_2max = to exhaustion	Bike	A/D strategy	•Continuous verbalizations of task-related thought content			•Dissociative thoughts more prevalent (78% of reported thoughts) during low-intensity cycling while associative thoughts more prevalent during moderate-intensity (61% of reported thoughts) and high-intensity (93% of reported thoughts) cycling
Johnson & Siegel[97]	•N = 26 W •Average age: 19.6±1.5 y	•Untrained •Average estimated VO_2max: 36.7±5.4 $ml \cdot kg \cdot min^{-1}$	•60% •90% VO_2max	5-min	Bike	•Active Dissociation (mental arithmetic) •Passive Dissociation (music) •Control condition	•RPE •PAQ	•HR		•No effect of A/D conditions on HR •Active Dissociation showed lower Fatigue at 90% VO_2max compared to Passive Dissociation and Control conditions •RPE lower for Active Dissociation compared to Passive Dissociation and Control conditions

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Johnson & Siegel[98]	•N = 44 W •Average age: 21.3±4.9 y	•Untrained •Average estimated VO_2max: 35.7±1.2$ml \cdot kg \cdot min^{-1}$	Submaximal		Bike	•Internal/External Dissociation •Association •Control	•RPE •PAQ	•HR		•No effect on HR •Association condition resulted in higher RPE compared to both Dissociation and Control conditions •Association condition resulted in greater Fatigue scores on PAQ compared to Internal Dissociation condition •No effect of A/D conditions on PAQ subscales of Task Aversion and Motivation
Kirkby[67]	•N = 1 W •Age: 38 y	•Trained •Ultraendurance athlete	Submaximal [competitive pace]	48-hr	Running	Self-reported A/D strategy	•POMS •Self-reported mood/pain •A/D strategy			•More associative thoughts (70.6%) compared to dissociative thoughts (29.4%) •Self-reported pain and negative mood increased throughout the race •Pain accounted for 90% of variance in negative mood •Only Confusion subscale of POMS did not return to baseline levels 3 days post-race
Koivula & Hassmén[89]	•N = 30 W •Average age: 27.4±4.0 y	•Moderately trained Average estimated VO_2max: •Externals: 45.9±8.9 $ml \cdot kg \cdot min^{-1}$ •Internals: 41.8±8.5 $ml \cdot kg \cdot min^{-1}$	Submaximal	Four 4-min stages	•Bike •Treadmill running	•External LoC (Ext) •Internal LoC (Int)	•Overall, Central, and Local RPE	•HR		•External LOC participants displayed higher RPE (overall, central, local) at each stage of cycle ergometry •Internal LOC participants displayed lower (not significant) RPE during treadmill running
LaCaille et al.[81]	•N = 60 (22 M / 38 W) •Average age: 26.8 y	Healthy	Submaximal	5 km	Running	•Association (HR) •Dissociation (music)	•TDRS •RPE •EFI		•Run time	•Association group more focused on internal processes and had faster running times •Dissociation group attended more to music and non-running processes •Outdoor running = highest levels of Positive Engagement, Revitalization, Tranquility, course satisfaction, and lowest levels of Physical Exhaustion and RPE
McDonald & Kirkby[50]	•N = 40 (20 M / 20 W) Average age: •M: 16.4 y •W: 15.9 y	•Trained •Competitive runners	Submaximal [competitive pace]	3-8 km	Running	Examination of A/D strategy by gender and ability level	•Questionnaire responses			•Less dissociation use as ability level increases, regardless of age
Martin et al.[116] Study 5	•N = 16 (5 M / 11 W) •Average age: 33 y	•Sedentary	60%-80% age-predicted HR_{max}	•3 $d \cdot wk^{-1}$ for •12 weeks	Walk/jog	•Association group •Dissociation group	•Adherence [attendance]		•Fitness status	• Dissociation group had better attendance (76.6%) compared to Association group (58.7%) •Self-reported adherence to a 3rd day out-of-class run was better for Dissociation group (57.2%) compared to Association group (46.9%) •Adherence to 3rd day out-of-class run significantly correlated with fitness improvements (r = 0.54) •Greater short- and long-term adherence in Dissociation group
Martin et al.[129]	•N = 18 M •Average age: 32.1±4.9 y	•Trained •Average VO_2max: 67.4±3.9 $ml \cdot kg \cdot min^{-1}$	Submaximal	10-min	Treadmill running	High vs. Low Self-attention	•SCAT •TAI •PSC	•RE		•High Self-Attention significantly correlated with running economy
Masters & Lambert[74]	•N = 48 (30 M / 18 F) •Average age: 33.4 y	•Trained •Competitive marathoners	Submaximal	42.5 km	Running	Self-reported A/D strategy	•Masters Reasons for Running a Marathon Scale •Marathon Race Diary			•93.75% prefer associative strategy during race •Preference for dissociation during training runs •Association related to faster performances •More important competition is, more likely to associate •Neither strategy related to injury
Masters & Ogles[56] Study 1	•N = 127 (113 M / 14 W) •Average age: 38.5 y	•Trained •Competitive marathoners	Submaximal	42.5 km	Running	Self-reported A/D strategy	•Running thoughts •Injury Checklist •MOMS			•Dissociation was used during 61% of training time & 32% of racing time •No relationship between dissociation and running injuries •Dissociation related to slower race times, less motivated by competition with other runners
Masters & Ogles[56] Study 2	•N = 188 (147 M / 41 W) •Average age: 37.8 y	•Trained •Competitive marathoners	Submaximal	42.5 km	Running	Self-reported A/D strategy	•AFQ •RAS •MOMS •SOQ			•Association related to increased injury risk

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Nietfield[138]	•N = 45 (25 M / 20 W) •Average age: 19.6±1.23 y	•Trained Mile average times: •Men: 4:29±13:35 min •Women: 5:27±26.76 min	Submaximal	1-mile	Running	Metacognitive strategies (including A/D strategy)	•RMQ •Racing Cognitions		•Pacing ability	•42% indicated associative focus (energy level, pain tolerance, running form)
Ogles et al.[57]	•N = 131 (104 M / 27 W) •Average age: M = 39.85±8.63 y W = 37.63±8.79 y	Average weekly mileage: •M = 48.33±16.21 mi W = 47.50±14.48 mi	Submaximal	Normal training run duration	Running	Questionnaire responses	•DES •BS •SIPI •TAS •TSQ •TRT •MOMS			Based on TSQ: •Internal focus reported 52.9% of time during races and 28.8% of time during training runs •External focus reported 10.1% of time during races and 45.9% of time during training runs Based on TRT: •External focus reported 67.9% of time and internal focus 30.6% of time during training run •Positive constructive daydreaming (SIPI) significantly correlated with percent time focusing on internal (r = -.27) and external stimuli thinking (r = .22), respectively •Competitors that used running to deal with emotional problems more likely to dissociate during a race •Runners that endorsed life meaning as reason for competing more likely to dissociate after a training run
Okwumabua[61]	•N = 90 (82 M / 8 W) •Average age: 35.5±9.0 y	•Trained •Marathon runners •Average workload: 52.2±14.6 m·wk^{-1}	Submaximal [competitive pace]	42.5 km	Running	Questionnaire responses				•Association significantly correlated with longest training run (r = .27), faster goal times (r = -.31), and even pace expectation (r = -.30) •Expected pain during competition and self-efficacy not related to A/D strategy •Greater reliance on association during competition
Okwumabua et al.[62]	•N = 279 (213 M / 66 W) Average age •M: 47.84 y •W: 47.03 y	•Trained •Marathon runners •Average training load: 27.40±16.77 m·wk^{-1}	Submaximal [competitive pace]	10 km	Running	Questionnaire responses				•Participants reported more dissociative thinking during the race compared to before or after •Greater percentage of associative strategies at each quartile of race compared to dissociative strategies •Dissociative strategies increase during first 3 quartiles of race
Padgett & Hill[77] Study 2	N = 12 M	Healthy	Submaximal	1-mile	Running	•Dissociation •External focus •Imagery	•Estimated Running Time •Estimated Effort		•Actual Running Time	•External focus produced fastest times and lower estimates of time and effort (nonsignificant)
Pennebaker & Lightner[40] Study 1	•N = 40 •College-aged	Healthy	Submaximal	10-min	Treadmill exercise	•Association (breathing) •Dissociation (ambient noise) •Control	•Self-reports of fatigue •Self-reported physical symptoms •Subjective ratings	•HR •BP		•Fatigue significantly increased during Association compared to Dissociation and Control •Greater physical symptoms during Association compared to Dissociation •Subjective assessment of Tension significantly greater during Association •HR and BP showed no changes
Rushall & Shewchuk[121]	N = 6 (2 M / 4 W)	•Trained •Age-group swimmers	Submaximal	800 m	Swimming	•Task-relevant thinking •Mood words •Positive self-talk			•Swim time	•Swimming performance improved between 2.5% & 3.1% with task-relevant thinking •Task-relevant thinking rated #1 by participants
Rushall et al.[127]	N = 18 (8 M / 10 W)	•Trained •National-level cross country skiers	Submaximal [competitive pace]	up to 130 sec	Cross-country skiing	•Task-relevant statements (i.e. association) •Mood words •Positive self-talk			•Ski times	•Increased HR for task-relevant statements, mood statements, & positive self-talk compared to control condition •Increased skiing performance for task-relevant statements, mood statements, & positive self-talk compared to control condition
Russell & Weeks[93]	N = 7 M	Healthy	75% HRmax	60-min	Bike	•Association (monitor HR) •Dissociation (count word "duck") •Control	•RPE •A/D strategy	•HR		•HR not affected by cognitive strategy •Higher RPE in dissociation trial •4 cyclists claimed Association ride easier; 3 said control ride easier
Sacks et al.[69]	N = 10 M	•Trained •Ultraendurance athletes	Submaximal [competitive pace]	100 miles	Running	Competitive environment	•Self-reported mood •A/D strategy •Cognitive performance			•3/10 completed the event •Mood scores progressively worsened over course of event •Mix of associative and dissociative thoughts •Feelings of pain viewed as signal to adjust pace, not unpleasant experience

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Schomer & Connolly[65]	•N = 31 •n = 12 *novice* (6 M / 6 W); •n = 10 *average* (6 M / 4 W); •n = 9 *elite* (6 M / 3 W); •Average age range: 25 - 37.8 y	•Trained •Marathon runners	Submaximal	Normal training run duration	Running	Recorded A/D strategy per training run quartile	•RPE •A/D strategy			•More dissociative strategies during first 3 quartiles of a training run until last quartile when association strategies increased significantly •Greater percentage of dissociation strategies at RPEs of 7-10, 11-12, 13-14 •Greater percentage of association strategies at RPE 15-18 •Females engaged in more personal problem solving while males engaged in more social conversation during training runs
Schomer[24]	•N = 31 (18 M / 13 W) •Age range: 25-38 y	Healthy	Submaximal	Normal training run duration	Running	Categorized A/D strategy as either: •Task-related (associative) •Task-unrelated (dissociative)	•RPE •A/D strategy			•Superior marathoners did not use association significantly more •Higher RPE associated with more associative content
Schomer[71]	•N = 31 •n = 12 *novice* (6 M / 6 W); •n = 10 *average* (6 M / 4 W); •n = 9 *elite* (6 M / 3 W); •Average age range: 25 - 37.8 y	•Trained •Marathon runners	Submaximal	Normal training run duration	Running	4-month A/D strategy training program	•RPE •A/D strategy			•Ability level not related to A/D strategy •Increases in RPE related to proportional increases in associative thinking across all ability levels •RPE for novice runners related to A/D categories of Affect/Feelings, Command/Instruction, Pace Monitoring •RPE for average runners related to same categories as novice runners in addition to category of Body Monitoring •RPE for superior runners related to A/D categories of Body Monitoring, Command/Instruction, Pace Monitoring
Schomer[72]	N = 10	Healthy	Submaximal	Normal training run duration	Running	•5-week A/D training •Association thinking reinforced •Dissociative thinking extinguished.	•RPE •Self-report questionnaire			•General trend for increases in training intensity (RPE) to result in greater associative thinking •8/10 used associative strategy with steady rise in training intensity •2/10 had quick rise in training intensity while associative strategy training did not keep pace.
Schomer[73]	•N = 10 case studies Age range: •M (n = 5): 24-48 y •W (n = 5): 27-44 y	•Trained •Marathon runners	Submaximal	Varied training distances	Running	•5-week A/D training •Association thinking reinforced •Dissociative thinking extinguished.	•RPE			•Association appeared to improve training quality and efficiency
Scott et al.[134]	•N = 9 (5 M / 4 W) •Average age: 20.23±1.88 y	•Trained •Competitive rowers	•Women: Level 2 resistance •Men: Level 3 resistance	40-min	Rowing	•Associative (rowing audiotape) •Dissociative music tape •Dissociative rowing videotape			•Distance rowed	•Rowing associative audiotape: 3.77% increase •Dissociative videotape: 1.27% increase •Dissociative music tape: 0.77% increase
Siegal et al.[102]	•N = 15 W •College-aged	Untrained	•300 $kpm \cdot min^{-1}$ •600 $kpm \cdot min^{-1}$ •900 $kpm \cdot min^{-1}$	2 min intervals	Bike	Arithmetic problems every: •3 sec (High dissociation) •5 sec (Moderate dissociation) •7 sec (Low dissociation)	•RPE	•HR	•Correct Responses	•No effect on RPE or HR •More correct responses with Low Dissociation •No Dissociation X Intensity interaction
Siegel et al.[140]	•N = 44 (8 M / 36 W) •Average age: 24.2±6.7 y	•Moderately trained •Average VO_2max: 40.9±7.9 $ml \cdot kg \cdot min^{-1}$	50% or 75% predicted VO_2max	4-min	Bike	•Association •Dissociation (distraction) •Control		•HR	•Total work •Time to reproduce work •Cadence	•Control condition performed significantly more work on Day 3 compared to Day 2 •Control condition worked for 80 sec longer compared to either attentional focus condition •No information x workload interaction or day x workload x information interaction
Silva & Appelbaum[51]	N = 32	•Trained •Competitive marathoners	Submaximal [competitive pace]	42.5 km	Running	Interviews and RSQ prior to Olympic Trials	•RSQ			•Top finishers use association more regularly; use dissociation later in the race to distract from discomfort •Lower finishers adopt dissociation earlier in the race •Top finishers report more self-talk as motivation.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Spink & Longhurst[120]	•N = 23 (14 M / 9 W) •Average age: 14.6±2.01 y	•Trained •Competitive swimmers	Submaximal [competitive pace]	400 m	Swimming	Association vs. Dissociation			•Swim time	•Association resulted in significantly faster swimming times
Stanley et al.[96]	•N = 13 W •Average age: 20.08±1.75 y	•Physically active •Average time spent cycling: 3.38±1.66 hrs·wk^{-1}	HR corresponding to 75% VO_2max	10-min	Bike	•Internal Association •Internal Dissociation •External Association •External Dissociation	•RPE			•RPE higher in both internal and external associative conditions compared to internal and external dissociative conditions •Effect sizes between Internal Association and a) Internal Dissociation (ES = .54) and b) External Dissociation (ES = .87) •Effect sizes between External Association and a) Internal Association (ES = .74) and b) External Dissociation (ES = 1.19) •Association resulted in higher RPE compared to Dissociation after collapsing conditions (ES = 2.04)
Stevinson & Biddle[26]	•N = 66 (56 M / 10 W) •Average age: 36.11 y	•Trained •Marathon runners	Submaximal [competitive pace]	42.5 km	Running	•Internal/task-relevant thoughts •External/task-relevant thoughts •Internal/task-irrelevant thoughts •External/task-irrelevant thoughts	•Retrospective recall of A/D strategy •Self-reports of "*hitting the wall*"			•"*Hitting the wall*" = internal/task-irrelevant thoughts •Internal/task-relevant thoughts = earlier onset (r = -0.39) and longer duration of "*the wall*" (r = 0.46) •External/task-irrelevant thoughts correlated with "*hitting the wall*" (r = 0.56)
Stevinson & Biddle[27]	N = 10	•Trained •Marathon runners	Submaximal [competitive pace]	42.5 km	Running	Self-reported A/D strategy	•Self-reported A/D strategy			•36.9% utilized internal/task-relevant strategy •28.4% utilized external/task-relevant strategy •26.1% utilized external/task-irrelevant strategy •8.4% utilized internal/task-irrelevant strategy •Internal/task-irrelevant most associated with "*hitting the wall*" (ES = .59)
Summers et al.[29]	•N = 363 (345 M / 18 W) •Average age: 36.1±4.9 y	•1st time marathoners •Average finishing time: 4:26 hrs	Submaximal [competitive pace]	42.5 km	Running	Retrospective recall	•A/D strategy prevalence			•69% dissociate during training run •63% used mixed attentional focus strategy during marathon
Takai[139]	•N = 60 M •Average age: 20.7±1.6 y	•Trained •Competitive runners •Average training load: 144.7±40.7 km·wk^{-1})	Submaximal [competitive pace]	20 km	Running	Retrospective recall of A/D strategy			•Self-set, predicted, actual run times	•Runners using more internal focus better able to reproduce running times and perform at a more steady pace
Tamman[91]	N = 8 (4M / 4 W)	•Trained •Average competitive experience: 8.88 y	•Submaximal (1500 m) •Maximal (2300 m)	•Four 1500 m •One 2300 m	Running	A/D strategy assessed post-exercise	•RPE •MRF	•HLa •HR •VO_2		•As intensity increased, runners felt they were working harder, focusing more on internal body sensations, felt more energized, more worried, and increased body tension
Tenenbaum & Connolly[53]	•N = 60 (30 M / 30 W) •Average age range: 16.1±2.4 to 19.7±2.1 y	•Trained •Competitive rowers: •Experienced (~ 5 y) •Novice (~ 4 months)	•30% •50% •75% maximum power	10 min	Rowing	Counterbalanced relative intensity levels of: •30% •50% •75% maximum power	•RPE •A/D strategy	•HR	•Watts	•RPE, HR, and Watts increased as exercise intensity level increased •A/D strategy was dissociative at low intensity, combined associative-dissociative at moderate intensity, and associative at high intensity •Novice rowers reported higher RPE at each relative intensity level compared to experienced rowers although experienced rowers produced greater wattage •Women novice rower reported greater associative thinking at each intensity level compared to experienced men and women, and novice men
Welsh et al.[117]	•N = 22 W •Average age: 35.7 y	•Sedentary •Average BMI: 25.96±3.88 kg/m^2	60-80% HR_{max}	•20-30 min •3 d·wk^{-1}	Walk/jog	•Internal self-statement group •External self-statement group •Control group	•STAI •BDI •LoC •JAS •SMI •Adherence			•Self-statements did not have an effect on distance run or exercise program compliance.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Wrisberg & Pein[54]	•N = 187 Experienced runners: •M (n = 49): 26.9±10.4 y •W (n = 38): 25.2±6.5 y Inexperienced runners: •M (n = 66): 22.9±6.5 y •W (n = 34): 22.4±6.4 y	•Moderately to competitive trained	Submaximal	Normal exercise run duration	Running	Post-run assessment of A/D strategies	•AFQ			•"Experienced" runners = dissociate more •Women tend to dissociate at both "experienced" and "inexperienced" level compared to men
Ib. Investigations of Attentional Association and Dissociation during self-selected or self-paced exercise.										
Baden et al.[95] Study 1	•N = 22 (14 M / 8 W) •Average age: 48±8.9 y	•Moderately trained •Club members •Average training distance: 8.86±2.2 m/run	Self-paced	8-10 miles	Running	Group run: •8 miles •10 miles	•RPE •%A/D strategy			•RPE increased over time, and was higher in short course vs. long course. No Condition X Distance interaction •%Associative Thoughts higher in short course vs. long course. No Distance main effect or Condition X Distance interaction. •Significant correlations between RPE and %Associative Thought on short course at mile 7.25 (r = 0.52) and on long course at mile 7.25 (r = 0.43) and mile 9.25 (r = 0.44)
Baden et al.[95] Study 2	N = 40; •Group 1: n = 22 (10 M / 12 W); •Average age: 65±5.95 y; •Group 2: n = 18 (10 M / 8 W); •Average age: 21.28±1.74 y	•Group 1: Physician recommended •Group 2: Healthy	Self-paced	10-min	Treadmill exercise	•Short condition (10 min) •Long condition (expected 20 min, but stopped at 10 min)	•RPE •%A/D strategy			•RPE increased over time for both conditions and was higher in Short condition compared to Long condition •%Associative thoughts increased over time in both conditions and trend for higher %Associative thoughts in Short condition compared to Long condition •Significant positive correlations between RPE and %Associative thoughts at mins 7 (r = 0.38) & 9 (r = 0.42) in Short condition and min 9 (r = 0.45) in Long condition
Butryn & Furst[80]	•N = 30 W •Average age: 31.0±10.45 y	•Moderately trained •Recreational runners •Average training load: 28.0±17.25 m wk^{-1}	Self-paced	4-mile	Running	Self-reported A/D strategy •Park •Urban	•POMS (short-form) •EFI •TDRS			•Both mood (TMD from POMS) and feeling states (Positive Engagement and Revitalization) significantly improved following run (no effect of setting) •Associative thoughts most prevalent across both settings •No significant correlations between association or dissociation with either POMS or EFI subscales
Couture et al.[99]	•N = 69 (36 M / 33 W) •Average age: 19.7 y	•Healthy •Physical education students	Self-paced	500 m	Swimming	•Association •Internal dissociation •External dissociation	•RPE •PFQ •SACT		•Swim time	•Association = 54.5s faster •Internal Dissociation = 1.13s faster •External Dissociation = 0.21s slower •Control group = 7.5s faster
Couture et al.[100]	•N = 22 (11 M / 11 W) •Average age: 27.0 y	•Moderately trained •Recreational swimmers	Self-selected pace	800 m	Swimming	Use of preferred A/D strategy	•RPE •SACT	•HR	•Swim time	Preference for: •association = 78.1%; •dissociation = 9.6%; •combination = 12.3% •Association occurred more often during middle part of swim •No difference in RPE, HR, or swim times
Fillingim & Fine[75]	•N = 15 (8 M / 7 W) •Age range: 18-38 y	Healthy	Self-selected pace	1-mile	Running	•Word cue (dissociation) •Breathing (association) •Control condition	•Symptom/Emotion Checklist: A State Measure		•Running time	•Dissociation condition reported fewer symptoms than other conditions •Exercise-relevant symptoms lower in dissociative condition •Mood more positive in dissociative condition •Shortness of breath, side cramps, fatigued, and pleased significantly contributed to positive mood in dissociative condition
Hollander & Acevedo[66]	•N = 8 (3 M / 5 W) •Average age: M = 42.0±21.46 y W = 28.8±2.48 y	•Trained •Endurance swimmers	Self-paced	~27 mi	Swimming	Post-swim interview	•A/D strategy			•More likely to use dissociation to complete event

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Miller & Donohue[133]	•N = 90 (45 M / 45 W) •Average age: 16.2±1.1 y	•Trained •Competitive runners	Self-paced ("*best of your ability*" instructions)	1.6 km	Running	Listening to: •Motivational statements and technique •Music •Blank CD			•Run time	•Motivational statements and music listening significantly improved running times
Okwumabua et al.[119]	•N = 31 (11 M / 20 W) •Average age: 21.4 y	Healthy	Self-paced	1.5 miles	Running	5-week program of 30-min of A/D & Relaxation training	•Self-report of A/D strategy		•Run time	•Dissociative group had slower pretest run times than other conditions •All participants became more associative over course of study •No difference in running times across conditions at posttest •However, post-test reassignment of attentional focus strategy revealed that dissociative
Padgett & Hill[77] Study 1	N = 20	Healthy	Self-selected pace	30-min	Bike	Association vs. Dissociation	•Subjective Effort/Time			•Distracted cyclists reported lower effort rating and lower subjective time elapsed
Pennebaker & Lightner[40] Study 2	•N = 13 (8 M / 5 W) •College-aged	Healthy	Self-paced	1.8 km	Running	•Cross-country course (XC) •Oval track (T)	•Self-reports of physical symptoms, fatigue, and mood	•HR •BP	•Run time	•XC produced faster times •No difference in physical symptoms self-report •XC produced more satisfaction and greater enjoyment •T produced more boredom and greater frustration •HR and BP showed no changes
Saintsing et al.[118]	•N = 50 (31 M / 19 W) •College-aged	Healthy	Self-paced	1.5 miles	Running	•Association (focus on technique) •Dissociation ("*Down*" every stride) •"*Psyching-up*" •Control			•Run time	•Association produced significant faster running times •Those in Association group used Association 62% of time needed to complete run •Those in Dissociation group used Dissociation 43% of time needed to complete run •Improvement found in both the Association group and Dissociation group was significant correlated with use of selected strategy
Weinberg et al.[22] Study 1	N = 40	Healthy	Self-selected pace	30-min	Running	•Association •Dissociation •Positive Self-Talk	•Perceived fatigue	•HR		•No difference in HR or perceived fatigue self-reports with any of cognitive strategies.
Ic. Investigations of Attentional Association and Dissociation during exercise near or at maximal intensity.										
Beaudoin et al.[92]	•N = 11 M •Average age: 32.36±3.56 y	•Trained •Average VO_2max: 70.48±3.52 ml·kg·min^{-1}	90% VO_2max	30-min	Treadmill run	Self-selected A/D strategy	•RPE •FS			•4/11 runners completed protocol •Finishers reported more associative focus than non-finishers •Non-finishers reported higher RPE and more negative FS at min 19 of run
Côté et al.[113]	•N = 17 •Average age: 22.3 y	Healthy	Maximal	To exhaustion	Bike	Cycling w/ hockey helmet at HR of: •115 bpm •145 bpm •160 bpm •180bpm •Recovery			•Verbal reaction time (RT)	•RT longer at HR of 180
Franks & Myers[105] Study 1	•N = 16 (8 M / 8 W) •College-aged	Healthy	Maximal	To exhaustion	Treadmill exercise	•Respond to questions during testing •Quiet condition	•RPE	•HR	•Time to exhaustion	•Women = higher HR at stage 1 compared to men •Lower HR during light workload (5 METS, 4.8 km/hr, 5% grade) •Tendency to stop sooner during Questioning trial
Franks & Myers[105] Study 2	•N = 20 W •College-aged	Healthy	Maximal	To exhaustion	Treadmill exercise	•Talk/No Talk [D/A] •No Talk/Talk [A/D]	•RPE	•HR	•Time to exhaustion	•No difference in HR at any stage of the test or in time to exhaustion between two conditions •Lower RPE while talking during Stage 2 (walking) and not talking during Stage 3 (running)
Hutchinson & Tenenbaum[143] Study 2	•N = 13 (7 M / 6 W) •Average age: 26.85±4.91 y	•Moderately trained Average VO_2max •Men: 48.1±10.83 ml·kg·min^{-1} •Women: 41.7±6.75 ml·kg·min^{-1}	•50% •70% •90% VO_2max	•50% and 70% VO_2max = 5 min; •90% VO_2max = to exhaustion	Bike	A/D strategy	•Continuous verbalizations of task-related thought content			•Dissociative thoughts more prevalent (78% of reported thoughts) during low-intensity cycling while associative thoughts more prevalent during moderate-intensity (61% of reported thoughts) and high-intensity (93% of reported thoughts) cycling

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Characteristics**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Johnson & Siegel[97]	•N = 26 W •Average age: 19.6±1.5 y	•Untrained •Average estimated VO_2max: 36.7±5.4 $ml \cdot kg \cdot min^{-1}$	•60% •90% VO_2max	5-min	Bike	•Active Dissociation (mental arithmetic) •Passive Dissociation (music) •Control condition	•RPE •PAQ	•HR		•No effect of A/D conditions on HR •Active Dissociation showed lower Fatigue at 90% VO_2max compared to Passive Dissociation and Control conditions •RPE lower for Active Dissociation compared to Passive Dissociation and Control conditions
Morgan et al.[32]	•N = 27 M •Average age: 22.1±2.11 y	•Moderately trained •Dissociation group (n = 13) VO_2max: 49.8±4.72 $ml \cdot kg \cdot min^{-1}$ •Control group (n = 14) VO_2max: 51.2±6.00 $ml \cdot kg \cdot min^{-1}$	80% MAP	To exhaustion	Treadmill exercise	•Dissociation •Placebo •Control	•RPE •STAI (modified 4-item)	•VO_2max •%VO_2max •RER •V_E •HR		•Dissociation group had lower values on all variables at 5th min except state anxiety •Dissociation had lower values on all variables during final min except HR, RPE, state anxiety. •Dissociation greater endurance time than control (7-min longer)
Salmela & Ndoye[114]	•N = 10 M •Average age: 22.2 y	•Moderately trained •Average VO_2max: 41.0 $ml \cdot kg \cdot min^{-1}$	Maximal	To exhaustion	Bike	Cycling w/ hockey helmet at HR of: •115 bpm •145 bpm •160 bpm •180bpm •Recovery			•Verbal reaction time (RT)	•From rest to HR 145, RT shows inverted-U response •After HR 145, RT significantly increases at HR 160 and 180
Smith et al.[128]	•N = 36 (27 M / 9 W) •Average age: 23.6±6.8 y	•Trained •Competitive runners •Average training load: 46.9±16.4 $m \cdot wk^{-1}$	Maximal	To exhaustion	Treadmill running	•Passive association (bodily sensations) •Active association (tense/relax muscles) •Control (university informational video)	•RSQ •POMS (short form) •RPE	•HR •V_E •VO_2		•Least economical runners = dissociative/less relaxation
Tamman[91]	N = 8 (4 M / 4 W)	•Trained •Average competitive experience: 8.88 y	•Submaximal (1500 m) •Maximal (2300 m)	•Four 1500 m •One 2300 m	Running	A/D strategy assessed post-exercise	•RPE •MRF	•HLa •HR •VO_2		•As intensity increased, runners felt they were working harder, focusing more on internal body sensations, felt more energized, more worried, and increased body tension
Welch et al.[106]	•N = 20 W •Average age: 23.2±4.8 y	•Physically inactive •Average VO_2peak: 33.6±5.7 $ml \cdot kg \cdot min^{-1}$	Maximal	To exhaustion	Bike	Self-reported A/D strategy	•FS •FAS •RPE •A/D Strategy			•Affect significantly declined between Min 1 and pre-VT and each minute thereafter •Perceived activation significantly increased throughout test •Attentional focus became more associative as test progressed
Wrisberg et al.[87]	•N = 20 (10 M / 10 W) •College-aged	Healthy	Maximal	To exhaustion	Treadmill running	•Internal focus (mirror/breathing) •External focus (movie)	•STAI •RPE	•HR •BP	•Time to exhaustion	•Men displayed higher HR and lower RPE during "light" workloads •Women displayed lower HR and higher RPE under internal focus

Physiological Abbreviations: A/D = Association/Dissociation; HR = Heart Rate; (%)VO_2 = (Relative) Oxygen Consumption; RR = Respiratory Rate; V_E = Minute Ventilation; $V_E/VO_2/VCO_2$ = Ventilatory Equivalents for O_2 and CO_2; HLa = Blood Lactate; Epi = Epinephrine; Norepi = Norepinephrine; RER = Respiratory Exchange Ratio; BP = Blood Pressure; RE = Running Economy

Questionnaire Abbreviations: FS = Feeling Scale; FAS = Felt Arousal Scale; RPE = Ratings of Perceived Exertion; EFI = Exercise-Induced Feeling Inventory; AFQ = Attentional Focus Questionnaire; POMS = Profile of Mood States; STAI = State-Trait Anxiety Inventory; SOQ = Sport Orientation Questionnaire; TSCI = Trait Sport-Confidence Inventory; CRS = Commitment to Running Scale; PFQ = Perceived Fatigue Questionnaire; SACS = Subjective Appraisals of Cognitive Strategies; PAQ = Physical Activity Questionnaire; SCAT = Sport Competition Anxiety Test; TAI = Trait Anxiety Inventory; PSC = Private Self-Consciousness [subscale of Self-Consciousness Scale Revised]; MOMS = Motivations of Marathoners Scale; RAS = Running Addiction Scale; BIS-BAS = Behavioral Inhibition-Behavioral Activation System; EPQ = Eysenck Personality Questionnaire; TDRS = Thoughts During Running Scale; BDI = Beck Depression Inventory; LoC = Locus of Control; JAS = Jenkins Activity Survey; SMI = Self-Motivation Inventory; MRF = Mental Readiness Form; RSQ = Running Styles Questionnaire; ARSQ = Adapated Running Styles Questionnaire; RMQ = Racing the Mile Questionnaire; DES = Dissociative Experience Scale; BS = Bliss Scale; SIPI = Short Imaginal Processing Inventory; TAS = Tellegen Absorption Scale; TSQ = Thinking Styles Questionnaire; TRT = Training Run Thoughts; SACT = Subjective Appraisals of Cognitive Thoughts

APPENDIX F: AUDIO-ONLY STIMULI TABLE

Table Ia. Investigations of auditory-only stimuli based on submaximal exercise intensity levels.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Ayres (1911)	N/A	•Trained •Competitive cyclists	Submaximal [competitive pace]	46 miles	Track cycling	Alternate between: •Music (M) •No music (NO)			•Speed	•Day 1 (20 miles) Speed averages: M = 21 $m \cdot hr^{-1}$; NO = 18.8 $m \cdot hr^{-1}$ •Day 2 (20 miles) Speed averages: M = 17.6 $m \cdot hr^{-1}$; NO = 16.7 $m \cdot hr^{-1}$ •Day 3 (6 miles) Speed averages: M = 22.5 $m \cdot hr^{-1}$; NO = 19.3 $m \cdot hr^{-1}$ •Speed improvements attributed to social facilitation, not the influence of music
Beaver (1976)	•N = 5 M	•Trained •Competitive runners	•8.5 $m \cdot hr^{-1}$ •9.5 $m \cdot hr^{-1}$ •10.5 $m \cdot hr^{-1}$	N/A	Treadmill running	Counterbalanced order of: •Fast Music (FM) •Slow Music (SM) •No Music (NO)		•VO_2	Stride: •Frequency •Length	•FM/SM = no effect on VO_2 •Decrease in stride frequency and increase in stride length in both FM and SM conditions except at 8.5 $m \cdot hr^{-1}$ listening to SM (increased stride frequency/decreasing stride length)
Beckett (1990)	•N = 32 (16 M/16 W) •Age range: 18-32 y	Healthy	60%-70% HR_{max}	30-min	Walking	Randomly assigned: •Continuous music (CM) [self-selected] •Intermittent music (IM) •No Music (NO)		•Recovery HR	•Distance traveled	•CM and IM = higher recovery HR (combined average: 59.33 bpm) compared to NO (51.66 bpm) condition •No difference between CM and IM conditions in recovery HR values •CM and IM = greater distance walked (combined average: 3.17 miles) compared to NO (2.81 miles) condition •IM = greater distance walked compared to CM condition
Boutcher & Trenske (1990)	•N = 24 W •Average age: 19.20±1.53 y	•Untrained •Est. VO_2max: 36.2±5.72 $ml \cdot kg \cdot min^{-1}$	•60% HR_{max} •75% HR_{max} •85% HR_{max}	3 Trials of 18 min	Cycle ergometry	Counterbalanced order of: •Self-selected music (SS) •Goggles/earplugs (SD) •Control (Con)	•RPE •FS	•HR		•SS = lower RPE (7.91) at low 60% HR_{max} compared to SD (8.48) •SD = lower RPE (11.77) compared to Con (12.21) at 75% HR_{max} •No difference in RPE between SS, SD, and Con at 85% HR_{max} •No difference in affect between SS, SD, and Con at 60% HR_{max} •SS = more positive affect (9.43) compared to Con (8.95) and SD (8.65) at 75% HR_{max} •SS = more positive affect (8.40) compared to SD (7.41) at 85% HR_{max} •SS = no difference in HR across intensities
Brownley et al. (1995)	•N = 16 (4 M / 12 W) •Age range: 19-28 y	•Trained (Est. VO_2max range: 52.0 - 59.0 $ml \cdot kg \cdot min^{-1}$) •Untrained (Est. VO_2max range: 43.0 - 50.0 $ml \cdot kg \cdot min^{-1}$)	•Low (HR: 120±10 bpm) •Moderate (HR: 140±10 bpm) •High (HR: 160±10 bpm)	3 stages of 10 min	Treadmill exercise	Counterbalanced order of: •Fast Music (FM) [tempo: 154-162 bpm] •Slow Music (SM) •No Music (NO)	•RPE •FS	•HR •RR •V_E •Cortisol		•FM = more positive affect at Low and High intensity for Untrained compared to Trained participants •RPE not affected by music •RR increased at all exercise intensities while listening to FM compared to SM and NO conditions •V_E increased listening to music in untrained subjects •Cortisol marginally higher after High intensity listening to FM
Claremont et al. (1986)	•N = 12 (2 M / 10 W) •Average age: 20.5±2.32 y	•Healthy •Average VO_2max: 43.14±7.55 $ml \cdot kg \cdot min^{-1}$	•Low (110 bpm) •Medium (128 bpm) •High (158 bpm)	22-min	Aerobics	Random assignment by intensity level with music: •Low (LM) •Medium (MM) •High (HM)		•HR •VO_2 •V_E •METS •$Kcal \cdot min^{-1}$		•MM and HM = differences with LM on VE (46.24 vs. 46.13 vs. 35.06), VO_2 (33.35 $ml \cdot kg \cdot min^{-1}$ vs. 34.65 $ml \cdot kg \cdot min^{-1}$ vs. 24.60 $ml \cdot kg \cdot min^{-1}$), METS (9.52 vs. 9.9 vs. 7.03), HR (150 bpm vs. 158 bpm vs. 137 bpm), and $Kcal \cdot min^{-1}$ (10.71 vs. 11.17 vs. 7.91).
Curnow & Turner (1992)	•N = 46 (11 M/35 W) •Average age: 19.17 y	•Physically active	Submaximal	20-min	Cycle ergometry	Random assignment: •Exercise (EX) •Music (M) •Exercise + Music (EM) •Control (Con)	Torrance Tests of Creative Thinking			•EX, M, and EM = improvements in fluency scores compared to Con condition [no difference in Originality or Elaboration subscale scores]
Elliott et al. (2004)	•N = 18 (8 M / 10 W) Average age: •M = 22.1±1.4 y •W = 21.7±0.7 y	•Healthy •Exercise science students	Submaximal [RPE = 13]	12-min	Cycle ergometry	Counterbalanced: •Motivational music (MM) •Oudeterous (OM) •No music (NO)	•FS		•Distance cycled	•MM (12.19) and OM (11.19) resulted in more positive affect compared to NO (6.13); no difference between MM and OM •MM (7.11 km) cycled greater distance compared to NO (6.41 km); no difference between MM and OM (6.87 km)

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Hagen et al. (2003)	•N = 60 (19 M/41 W) •Average age: 78.3 y	Long-term care facility residents	Submaximal	•10-week program •3 d wk^{-1} •40-min	Exercise therapy program	•Occupational therapy (OT) •Musical movement exercise (MME) •Control (Con)	•LSI	•Physical Assessment	•Cognitve / Behavioral Assessment	•MME = significant increases in balance, joint flexibility, cognitive abilities, behavioral ratings, and life satisfaction measures compared to Con condition •MME = significnat improvement in life satisfaction, balance, and selected flexibility measures compared to OT condition
Hayakawa et al. (2000)	•N = 16 F •Average age: 49.9±7.5 y	Physically active	60% - 90% HR_{max}	60-min	Aerobics	•Japanese folk (JF) •Aerobic dance (AD) [tempo for each: 120 bpm] •No music (NO)	•POMS •RPE	•HR		•AD = increased Vigor compared to JF and NO conditions •NO = increased Fatigue compared to JF and AD conditions •AD = higher RPE at min 40 compared to NO condition •AD = higher HR at min 20 compared to NO condition
Johnson & Siegel (1992)	•N = 26 W •Average age: 19.6±1.5 y	•Untrained •Average estimated VO_2max: 36.7±5.4 ml kg min^{-1}	•60% •90% VO_2max	5-min	Cycle ergometry	•Mental arithmetic (MA) •Music (M) •Control (Con)	•RPE •PAQ	•HR		•MA and M = no effect on HR •MA = lower Fatigue at 90% VO_2max compared to M and Con conditions •MA = lower RPE compared to M and Con conditions
Karageorghis & Deeth (2002)	•N = 24 M •Average age: 20.3±0.9 y	Physically active	65% VO_2max	Three 10-min trials	Shuttle run	•Motivational music (MM) •Oudeterous music (OM) •No music (NO)	•Flow State Scale			•MM = greater Action-Awareness Merging, Clear Goals, Unambiguous Feedback, Concentration on Task at Hand, Transformation of Time, and Autotelic Experience compared to NO condition
Karageorghis et al. (2007)	•N = 29 (15 M/14 W) Average age: •M = 20.4±1.4 y •W = 20.7±1.1 y	Physically active	70% maximal HRR	Time to reach 70% max HRR	Treadmill exercise	Randomized order of: •Fast music (FT) [140-145 bpm] •Medium music (MT) [115-120 bpm] •Mixed music (MIX) •No music (NO)	•IMI •Flow State Scale-2			•Preference for MT compared to FT and MIX IMI subscales: •Interest-Enjoyment = higher for MT compared to MIX condition; NO = lower compared to FT, MT, MIX •Pressure-Tension = lower for MT compared to NO and FT; MIX compared to NO •Global Flow = NO lower compared to FT, MT, and MIX conditions
Karageorghis et al. (2006)	•N = 29 (15 M/14 W) Average age: •M = 20.3±1.1y •W = 20.4±1.3 y	Healthy	HRR of: •40% •60% •75%	12-min	Treadmill walk	Random order of music at: •80 bpm •120 bpm •140 bpm	•Music tempo preference			•Preference for high music tempo (140 bpm) over medium (120 bpm) tempo music at 75% maxHRR only •Decrease in preference for slow (80 bpm) music compared to medium (120 bpm) and fast (140 bpm) music conditions at 60% maxHRR •Medium (120 bpm) and fast (140 bpm) preferred at all exercise intensities over slow (80 bpm) tempo music.
Kim & Koh (2005)	•N = 10 (1 M / 9 W) •Average age: 67 y	Stroke patients	20-min	8-week program	Stroke rehab exercises [upper body]	Random assignment: •Song (S) •Karaoke (K) •No music (NO)	•Perceived pain			•S, K, and NO = no difference in perceived pain reports
Loucks (2000)	•N = 15 •Age range: 19-22 y	•Healthy •Physical education students	65%-85% HRmax	20-min	Treadmill exercise	•Upbeat Music (UP) [tempo: 140 bpm] •Slow Music (SM) [tempo: 100 bpm] •No Music (NO)	•RPE	•HR		•No difference in RPE between UP, SM, and NO conditions •No difference in HR between UP, SM, and NO conditions
MacNay (1995)	•N = 4 •Age range: 45-65 y	Cardiac rehabilitation patients	Submaximal	15 sessions of 30-min	Cardiac rehab exercises	•Preferred Music (PM) •No Music (NO)	•RPE •FS		•Time estimation	•PM = lower RPE in 3/4 patients •PM = more positive affect in 2/4 patients, 1/4 reported no affect change, 1/4 reported worse affect [affect ratings between -2 and +4] •PM = lower time estimation in 2/4 patients
Macone et al. (2006)	•N = 27 (14 M/13 W) •Average age: 22.0±2.9 y	•Moderately trained	75% HRR	To exhaustion	Treadmill running	Random assignment to: •Music (M) [tempo: 140 bpm] •No music (NO)	•POMS •STAI		•Time to exhaustion	•M and NO = lower Tension, Depression, Confusion, and State Anxiety •NO (1.23) = less Fatigue in Women compared to Music (5.38) •M (34 min) = longer time to exhaustion compared to NO (30 min) condition •M (29 min) = longer time to exhaustion for Women compared to NO (21 min) condition

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Mathews et al. (2001)	•N = 18 (1 M / 17 W) •Average age: 85 y	Residential dementia patients	Submaximal	22-min	PT rehab exercises	Multiple baseline design: •Music (M) •No music (NO)			•Observation of physical activities	•M = increased participation rates (69%, 68%) compared to NO condition (53%, 41%)
Murrock (2002)	•N = 30 (17 M / 13 W) •Age range: 52-84 y	Phase II cardiac rehabilitation patients	65%-85% HR_{max}	•10 sessions •40-min	Aerobic exercise machines	Random assignment: •Classical music (CM) [tempo: 128-160 bpm] •No music (NO)	•Modified RPE •FS	•HR		•CM = no difference in RPE (3.2) compared to NO (3.4) condition •CM = significant difference in affect (4.13) compared to NO (0.33) condition •HR not reported.
North & Hargreaves (2000) Study 1	•N = 48 (24 M/24 W) •Average age: 19.27±2.06 y	Healthy	Submaximal	2-min	Cycle ergometry	Music: •Low arousal (LA) [tempo: 80 bpm] •High (HA) arousal [tempo: 140 bpm] with random assignment: •During Relaxation (RELAX) •During Exercise (EX)	Ratings of: •Liking •Appropriate		•Listening time	•Ratings of Appropriateness = LA rated more appropriate during RELAX and HA rated more appropriate during EX •Listening time = EX spent more time listening to HA (80.1%) compared to LA (19.9%) music and RELAX spent more time listening to LA (80.2%) compared to HA (19.8%) music •Ratings of Liking = EX liked HA better than LA music and RELAX liked LA better than HA music •Correlations between Liking and Listening time = HA (r = 0.74) and LA (r = 0.67).
North & Hargreaves (2000) Study 2	•N = 48 (10 M/38 W) •Average age: 18.75±1.12 y	Healthy	Submaximal	2-min	Cycle ergometry	Music: •Low arousal (LA) [tempo: 80 bpm] •High (HA) arousal [tempo: 140 bpm] with random assignment: •Post-relaxation (RELAX) •Post-exercise (EX)	Ratings of: •Liking •Appropriate •Typicality		•Listening time	•HA and LA = no difference in ratings of typicality during RELAX and EX conditions •Ratings of Liking = no difference between RELAX and EX conditions for LA or HA music •Listening time = EX condition spent more time listening to LA (70.9%) compared to HA (29.1%) music; no difference for RELAX (LA: 50.7% vs. HA: 49.3%) condition
Potteiger et al. (2000)	•N = 27 (14 M/13 W) Average age: •M = 23.3±2.7 y •W = 23.5±2.9 y	•Healthy •Average VO_2peak: M = 39.4±4.7 $ml \cdot kg \cdot min^{-1}$ W = 37.6±4.7 $ml \cdot kg \cdot min^{-1}$	70% VO_2peak	4 trials of 20 min	Treadmill exercise	Counterbalanced order of: •Self-Selected (SS) •Fast Music (FM) •Classical Music (CM) •No Music (NO) [tempo range: 60-65 to 140-145 bpm]	RPE: •Peripheral •Central •Overall	•HR		•SS, FM, CM = lower peripheral RPE at mins 10, 15, and 20 compared with NO condition •NO = higher central RPE at mins 5 compared to FM; min 10 compared to FM and CM; min 15 compared to CM; at min 20 compared to FM and CM •NO = higher RPE compared to SS, FM, CM at mins 5, 10, 15, 20 •No change in HR between SS (161.1 bpm), FM (160.4 bpm), CM (160.7 bpm), NO (161.0 bpm) conditions.
Seath & Thow (1995)	•N = 34 (4 M / 30 W) •Average age: 19.0± 3.6 y	•Physio-therapy students Average activity: •2 $d \cdot wk^{-1}$ •20 min/session	Submaximal [60-80% predicted HR_{max}]	2 classes of 25-min	Aerobics	Random order of: •Pop music (PM) •Metronome (M) [tempo for each: 132 bpm]	•RPE •FS	•HR (n = 6)		•PM = more positive affective responses compared to M •PM = significantly lower RPE compared to M •HR = no difference between PM and M (both within 60-80% age predicted HR_{max})
Smedzra & Bacharach (1998)	•N = 10 M •Average age: 25.1±6.02 y	•Trained •Average VO_2max: 63.36±7.04 $ml \cdot kg \cdot min^{-1}$	70% VO_2max	15 min	Treadmill running	Randomized order: •Classical music (CM) •No music (NO)	•RPE	•HR •HLa •Norepi •RPP •SBP		•CM = lower values of RPE (12.9) compared to NO (14.4) condition •CM = lower HLa (2.13 $mmol \cdot l^{-1}$ vs. 2.75 $mmol \cdot l^{-1}$), Norepi (694.1 pg/ml vs. 841.5 pg/ml), SBP (151.7 mmHg vs. 158.1 mmHg) compared to NO condition •CM = 17.5% lower Norepi (ES = 0.52) compared to NO condition •CM = lower mean HR (145.9 bpm vs. 152.9 bpm) and RPP (222.1 vs. 242.2) •CM = lower HR at Min 12 (144.1 bpm vs. 153.3 bpm), 15 (147.2 bpm vs. 156.1 bpm), and Recovery (9.8% lower) compared to NO condition •CM = lower SBP at mins 9 (4.8%) and 15 (3.6%) compared to NO condition •CM = lower RPP at mins 12 (219.8 vs. 241.6), 15 (226.6 vs. 248.5), and Recovery (125.5 vs. 148.4)

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Steptoe & Cox (1988)	•N = 32 W •Average age: 20±1.06 y	•Healthy Average Est. VO_2max: •Fit group: 2.99±0.59 l·min^{-1} •Unfit group: 2.24±0.18 l·min^{-1}	•Low (25 W) •High (100 W)	8-min	Cycle ergometry	Randomized order: •Music •Metronome	•RPE •POMS •STAI	•HR		•Music = no effect on trait anxiety, mood states or HR compared to metronome •Metronome (11.39) = higher RPE compred to music (10.92)
Uppal & Datta (1990)	•N = 51 F •Average age: 13.0 y	•Healthy •Physical Educations students	Submaximal	•6-week program •3 d·wk^{-1}	Physical education class activities	Random assignment: •Music (M) •No Music (NO) •Control (Con)		•HR •BP •Dynamic cardio-pulmonary index	•Breath holding time	•M and NO = significant reduction in HR compared to Con condition •M = significantly higher systolic BP compared to NO condition
Urakawa & Yokoyama (2005)	•N = 12 W •Average age: 21.9 y	Healthy	40%-60% age-predicted HR_{max}	15-min	Cycle ergometry	Rest/Exercise/Rest with: •Music (M) • No music (NO)		•HRV		•M = increase in LF/HF ratios compared to NO condition •M and NO = no difference in absolute HR •M = significant correlation (r = 0.881) between pre- and post-exercise LF/HF.
Van de Winckel et al. (2004)	N = 25 W Average age: •Exercise group (n = 15) 81.33±4.24 y •Control group (n = 10) 81.90±4.18 y	Dementia patients	Submaximal	30-min	Exercise therapy program	Random assignment: •Music/Exercise (ME) •No Music/Control (Con)	•MMSE •ADS-6 •BOP			•ME = improvement in MMSE mean score between 12.87 - 15.53 points compared to Con condition •2.67 point difference in improvement ME and Con on MMSE is clincially relevant (ES = 0.5) •ME = 10 - 14 point improvement on ADS-6 compared to Con condition
Yamashita et al. (2006)	•N = 8 M •Average age: 21.0±0.9 y	•Moderately trained •Average VO_2max: 49.2±5.0 ml·kg·min^{-1}	•40% •60% VO_2max	30-min	Cycle ergometry	Random order of: •Favorite music (FM) •No music (NO)	•RPE	•HR •HRV		•M and NO = no difference in RPE at 60% VO_2max condition •M = lower RPE at min 18 and end during 40% VO_2max condition •M and NO = no difference in HR •M and NO = no difference in rate of change in HFA

Table Ib. Investigations of auditory-only stimuli based on self-selected or self-paced exercise intensity levels.

Atkinson et al. (2004)	•N = 16 M •Average age: 25.0±5.0 y	Physically active	Self-selected	10 km	Cycle ergometry	Counterbalanced order of: •Trance music (TM) [87 dB; 142 bpm] •No music (NO)	•RPE •BMRI	•HR	•Speed •Watts	•Time to complete faster with TM (1030 sec) compared to NO (1052 sec) •Means for Speed, HR, and Watts higher with TM •TM = significantly higher speed at mins 1-3 compared to NO condition •Mean RPE higher throughout trial with TM •Participants more motivated by Rhythm Response qualities compared to Musicality, Association, and Cultural Aspects of TM
Bartholomew & Miller (2002)	•N = 204 W •Average age: 20.27±2.09 y	•Physically active •Average BMI: 21.80±2.86 kg·m^{-2}	Self-selected	40-min	Aerobics	Naturalistic setting	•RPE •AD-ACL •PANAS			•RPE = 14.2 •Aerobics = significant reductions for Negative Affect, Tension, and Tiredness at 5- and 20-min post-exercise compared to baseline values •Aerobics = significant improvements in Positive Affect and Energy at 5- and 20-min post-exercise compared to baseline values
Bauldoff et al. (2002)	•N = 24 (4 M / 20 W) •Average age: 68.1±8.0 y	•Moderate to severe COPD patients •Average FEV1: 41.3±13.0%	Self-selected	•8-week program •20-45 min •2-5 d.wk-1	Walking	Random assignment: •Preferred music (PM) [tempo: 90-110 beats] •No music (NO)	•Perceived dyspnea •STAI •CES-D •HRQoL •GQoL •modified RPE •Adherence		•Distance walked	•PM = significantly lower perceived dyspnea, greater distance walked (+445 ft vs. -169 ft) compared to NO condition at 8-weeks •PM = no difference in depressive symptoms compared to NO condition •PM = no differences in anxiety, health-related or global quality of life, and breathlessness/fatigue at end of walk test •PM = 24% increase in total distance walked (19.1 miles) compared to NO (15.4 miles) condition

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	Sample	Fitness Status	Intensity	Duration	Mode	Conditions	Psych	Physio	Perform	Results
Becker et al. (1995)	•N = 20 (10 M/10 W) •Age range: 60-101 y	Healthy	Self-selected	90 sec	Walking	•Frenetic Music (FM) •Mellow Music (MM) •White Noise (WN) •Scented headphones: Peppermint (P), Chamomile (C), and Unscented (Un)			•Distance walked	•FM and WN = greater distance walked compared to MM •No effect of scented headphones on walking distance
Brooks et al. (2003)	•N = 30 •Average age: 70±7 y	COPD patients	Self-selected	10-min	Walking	Crossover randomization: •Classical music (CM) •No music (NO)	•Perceived dyspnea •STAI		•Distance walked	•CM and NO = no difference on perceived dyspnea, state anxiety, or distance walked •CM and NO = significant increase within conditions on perceived dyspnea and state anxiety over time
Cohen et al. (2007)	•N = 25 (5 M / 20 W) •Age range: 18-29 y	Healthy	Self-selected	45 min or to exhaustion	Cycle ergometry	Counterbalanced order of: •Music alone (M) [preferred] •Money alone ($) •Music + Money (M$) •Control (Con)			•Minutes cycled •Number of revolutions	•$ and M$ conditions significantly increased minutes cycled; M did not •M, $, and M$ conditions significantly increased number of revolutions •Compared to Con condition: M = 9.3% increase in minutes cycled; $ = 33.4% increase in minutes cycled; M$ = 35.8% increase in minutes cycled •Compared to Con condition: M = 4.5% increase in pedaling rate; $ = 12.8% increase in pedaling rate; M$ = 18.1% increase in pedaling rate •More participants cycled for 45 min under $ and M$ compared to M or Con conditions
Dwyer (1995)	•N = 34 W •Average age: 27.4±8.6 y	•Healthy •Average aerobics experience: 3.3±3.0 y	Self-paced	25-min	Aerobics	Randomly assigned to: •Perceived Music Choice group (PM) •Control group (Con)	•IMI			•PM = greater perceived choice in music selection on aerobics video compared to Con group •PM = higher enjoyment (39.6), perceived competence (16.1), effort (23.4) and total intrinsic motivation (104.5) compared to Con (33.5; 13.6; 18.5; 87.7, respectively)
Edworthy & Waring (2006)	•N = 30 (15 M/15 W) •Age range: 18 - 63 y	Healthy	Self-selected	5 trials of 10-min	Treadmill running	Counterbalanced: •Loud/Fast music (LF) [80 dB/200bpm] •Loud/Slow (LS) [80 dB/70 bpm] •Quiet/Fast (QF) [60 dB/200 bpm] •Quiet/Slow (QS) [60 dB/70 bpm] •No music (NO)	•RPE •FS	•HR	•Speed	•RPE = increased over time between all music conditions •FS = more positive with music compared to no music •Fast music, regardless of loudness, = higher HR •LF = in higher HR compared to QF condition •LS and QS = no difference in HR •LF and QS = faster treadmill speeds compared to other conditions
Elliott et al. (2005)	•N = 18 (8 M / 10 W) Average age: •M = 21.2±0.9 y •W = 20.7±1.1 y	•Healthy •Sport science students	Self-selected	20-min	Cycle ergometry	Counterbalanced: •Motivational music (MM) •Oudeterous music (OM) •No music (NO)	•RPE •FS •Attitude toward Exercise Experience		•Distance cycled	•MM = more positive affect (2.24) compared to NO (0.29) and OM (1.62) conditions •MM and OM = higher RPE after min 8 compared to NO condition •MM (22.0) and OM (17.8) = more positive attitude immediately and 24-hr post-exercise compared to NO (8.1) condition •MM (9.94 km) and OM (9.85 km) = greater distance cycled compared to NO (8.93 km) condition
Kendzierski & DeCarlo (1991) Study 1	•N = 37 (20 M/17 W) •Age range: 18 - 24 y	Healthy	Self-selected	20-min	Cycle ergometry	Counterbalanced: •Self-Selected Music (SS) •No music (NO)	•PACES •Boredom Proneness Scale	•HR	•Distance cycled	•SS = higher PACES scores (96.27) compared to NO (81.05) condition •Significant correlation (r = -0.30) between PACES and Boredom Proneness Scale in NO condition •SS and NO = no difference in HR •SS = greater distance cycled (4.87 miles) compared to NO (4.72 miles) condition
Matesic & Cromartie (2002)	•N = 12 M •Age range: 18-23 y	•Trained (n = 6) Average body fat: 14.7% •Untrained (n = 6) Average body fat: 19.3%	Self-selected	20-min	Running	Alternate between: •5-min Music (M) •5-min No music (NO)	•RPE	•HR	•Lap pace	•M = signficantly lower RPE (13.4) compared to NO (17.5) for untrained subjects only •M = signficantly lower HR (176.3 bpm) compared to NO (183.6 bpm) for untrained subjects only •M = faster lap pace for both Trained (52.25 sec) and Untrained (49.75 sec) compared to NO (55.22 sec and 54.6 sec, respectively) •Untrained had faster lap times with M compared to Trained participants

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Miller & Donohue (2003)	•N = 90 (45 M/45 W) •Average age: 16.2±1.1 y	•Trained •Competitive runners	Self-paced ("*best of your ability*" instructions)	1.6 km	Running	Listening to: •Motivational statements and technique (MOT) •Preferred Music (PM) •Blank CD (BCD)	Perceived: •Improvement •Satisfaction		•Run time	•No difference between MOT and PM on perceived improvement and satisfaction •MOT = 8 sec running time improvement (ES = .99) •PM = 5 sec running time improvement (ES = .76)
North & Hargreaves (1996)	•N = 100 (7 M / 93 W) Average age: •Aerobics group (n = 50): 31.9±9.66 y •Yoga group (n = 50): 29.7±11.98 y	Healthy	Self-selected	20-min	•Aerobics •Yoga	Musical excerpts of varying complexity with random assignment: •Aerobics class (AC) •Yoga class (YC)	Ratings of music: •Liking •Complexity •Appropriate			•YC = inverted-U relationship between ratings of Liking and Complexity •AC = quadratic relationship between ratings of Liking and Complexity •YC & AC = linear relationships between ratings of Liking and Appropriateness •AC = inverted-U relationship between ratings of Liking and Complexity •YC = inverted-U relationship between ratings of Appropriateness and Complexity •AC = quadratic relationship between ratings of Appropriateness and Complexity
Pfister et al. (1998)	•N = 19 (11 M / 8 W) •Average age: 71.9±7.8 y	•COPD patients •Average FEV1: 40±11%	Self-selected	6-min	Walking	•Preferred music (PM) [tempo: 119-126 bpm] •No music (NO)	•RPE •Perceived dyspnea	•HR		•PM = no difference in RPE or perceived dyspnea compared to NO condition •60% reported enjoying exercising to music •PM = no difference in distance walked (331 m) compared to NO (321 m) condition [11 out of 19 participants walked further in PM condition]
Tenenbaum et al. (2004) Study 3	•N = 25 •Average age: 22.35 y	•Healthy •Physical Education students	Self-selected	2.2 km	Running	•4 competitive runs w/ matched partner (Conditions: RM, IM, DM, NO) •4 runs alone (Conditions: RM, IM, DM, NO)	•Exercise thoughts •Attentional focus		•Running endurance	•No effect on running times between music conditions and between running conditions •Music = no difference in exertion levels across running conditions; competitive run more demanding than run-alone •Music, in general, more effective at beginning compared to middle and end of run •~25% reported felt pain or discomfort regardless of music condition •30%-50% reported feeling pains in legs, back, chest and difficulty with dry mouth and breathing regardless of music condition •DM and RM less likely to motivate participants to run faster
von Leupoldt et al. (2007)	•N = 20 (12 M / 8 W) •Average age: 65±10 y	•COPD patients •Average FEV1: 55.9±18.8%	Self-selected	6-min	Walking	Counterbalanced: •Upbeat music (UM) •No music (NO)	•PANAS •Perceived dyspnea •Modified RPE •VAS-I •VAS-U	•HR •SpO_2 •FEV1	•Distance walked	•UM and NO = no difference in HR, FEV1, SpO_2, and distance walked •UM = lower RPE (2.4) compared to NO (2.8) condition •UM = lower VAS-U (0.3) compared to NO (1.8) condition •UM and NO = no difference in VAS-I •UM = higher positive affect ratings (31.5) compared to NO (29.5) condition •UM and NO = no difference in negative affect ratings
Wininger & Pargman (2003)	•N = 282 W •Average age: 21.1±4.2 y	•Physically active	Self-selected	~60-min	Aerobics	Naturalistic setting	•PACES •EIS •Preference ratings			•Exercise Enjoyment = significantly correlated with Music (r = .45), Instructor (r = .44), EIS (r = .34) •Music tempo = 17% of variance in Exercise Enjoyment •Satisfaction with Music, Satisfaction with Instructor, and Exercise-Role Identity accounted for 21%, 8%, and 3% of variance in Exercise Enjoyment

Table Ic. Investigations of auditory-only stimuli based on near or at maximal exercise intensity levels.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Anshel & Marisi (1978)	•N = 32 (16 M / 16 W) •Age range: 19-22 y	•Healthy •Physical education students	Submaximal	To exhaustion	Cycle ergometry	•Synchronized music/movement (SM) •Asynchronized music w/ strobe light (AM) [tempo: 125-135 bpm] •No music (NO)			•Endurance time	•SM = longer endurance time (12.61 min) compared to AM (10.64 min) and NO (9.92 min) conditions •Males (13.31 min) longer to fatigue time compared to females (9.04 min)
Becker et al. (1994)	•N = 60 •Children (n = 20) Age range: 9 - 11 y •Adults (n = 20) Age range: 18 - 55 y •Older adults (n = 20) Age range: 60 - 80 y •Equal M / W	Healthy	Maximal	2 min	Cycle ergometry	Predetermined excerpts listened prior to exercise in random order: •Frenetic Music (FM) •Mellow Music (MM) •White Noise (WN)			•Distance ridden	•MM (.91 miles) and FM (.91 miles) = greater distance cycled compared to WN (.76 miles) •Children and Adults = greater distance cycled with MM and FM compared to Older adults
Bharani et al. (2004)	•N = 20 M •Average age: 26.9±2.8 y	Untrained	Maximal	To exhaustion	Treadmill running	Randomized order: •Self-selected music (SS) •No music (NO)	•RPE	•HR_{peak} •RPP	•Time to exhaustion	•SS = lower RPE (6.5) compared to NO (7.6) condition •SS = higher HRpeak (201 bpm) and peak RPP (34,674) compared to NO (195 bpm; 32,192) condition •SS = longer exercise time (879 sec) compared to NO (764 sec) condition
Brilla & Hatcher (2000)	•N = 22 (M/W) •Age range: 21-34 y	•Physically active	Maximal	To exhaustion	Treadmill exercise	Random assignment: •Antecedent binaural stimulation (ABS) [tempo: 200+ bpm] •No Sound (NO)	•RPE	•HR •VO_2 •V_E •BP •RR •RQ	•Time to exhaustion	•ABS and NO = no difference in maximal HR (195.3 bpm vs. 192.7 bpm), V_E (132.3 $L{\cdot}min^{-1}$ vs. 132.1 $L{\cdot}min^{-1}$), or RPE (18.3 vs. 18.0) •ABS = greater VO_2max (49.8 $ml{\cdot}kg{\cdot}min^{-1}$ vs. 46.7 $ml{\cdot}kg{\cdot}min^{-1}$), RR (49.1 $br{\cdot}min^{-1}$ vs. 47.1 $br{\cdot}min^{-1}$), time to exhaustion (16.0 min vs. 15.5 min) and lower RQ (1.17 vs. 1.23) compared to NO condition
Copeland & Franks (1991)	•N = 24 (11 M / 13 W) •College-aged	Healthy	2-3 MET increase every 2 min	To exhaustion	Treadmill exercise	Preselected: •Fast Music (FM) [75-85 dB; 140 bpm] •Slow Music (SM) [60-70 dB; 100 bpm] • No Music (NO)	•RPE	•HR	•Endurance time	•SM = lower RPE compared to NO •FM and Con = higher HR at mins 1 and 6 compared to SM •SM = higher HR 1-min prior to and at max compared to FM and NO •SM = longer time to exhaustion compared to NO •No difference between FM and SM on endurance time
Coutts (1961)	•N = 15 M •College-aged	•Healthy •Physical education students	Maximal	75 revolutions	Cycle ergometry	Counterbalanced 2-min: •Fast Classical music (FC) •Slow Classical music (SC) •No Music (NO)		•HR	•Distance cycled	•Music, in general, did not influence HR or distance traveled compared to NO condition
Crust (2004)	•N = 15 F •Average age: 19.5±1.3 y	•Untrained •Predicted VO_2max: 35.8±2.4 $ml{\cdot}kg{\cdot}min^{-1}$	Maximal	To exhaustion	Treadmill exercise	Counterbalanced: •Familiar music (FM) [tempo: 120 bpm] •Unfamiliar music (UM) •White noise (WH)	•Music Motivation	•HR	•Walk time	•FM rated as more motivational than UM •No difference in HR between conditions •FM (ES = 0.50) and UM (ES = 0.67) conditions resulted in longer walk times compared to WH condition •No difference between FM and UM on walk times

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
DeBourdeaudhuij et al. (2002)	•N = 30 (10 M/20 W) •Average age: 13.1±2.0 y	•Obese •Average BMI: 33.5±4.9 kg m^2	Maximal	To exhaustion	Treadmill exercise	Counterbalanced: •Music (M) [preferred] •Control (Con)	Perceived •Bodily symptoms •Annoyance •Thoughts of carrying on	•HR_{peak} •RER •VO_{2peak}	•Running time	•M = more pleasant treadmill experience, higher HR_{peak}, RER, $VO_{2peak, and}$ longer running time (+60 sec) •M = less perceived bodily symptoms and fewer thoughts about carrying on •No difference in perceived annoyance
Dillion (1952)	•N = 240 •College-aged	Healthy	Maximal	40-yd	Swimming	Randon assignment: •Music (M) •No music (NO)			•Swim time	•M = mean improvement in swim time between 3.43-5.81 sec compared to NO (2.67-4.50 sec) condition •Correlations between music rhythm and swim time improvement range between r = -0.18 to r = 0.14
Dorfman (1987)	•N = 45 M •Age range: 18-22 y	Sportsmen	Maximal	To exhaustion	Step-test	Music selections of Joy (J) and Suffer (S) played to participants divided by strength of nervous system: •Strong (SNS) •Weak (WNS)			•Duration •Step number •Power •Work volume	•SNS = greater duration (104.1 sec vs. 93.6 sec), work volume (44.7 kgm/kg vs. 38.3 kgm/kg), and step number (67.4 vs. 57.3) compared to WNS under Joy music •WNS = greater power (26.7 kgm/min/kg vs. 24.7 kgm/min/kg) compared to SNS under Suffer music
Eliakim et al. (2007)	•N = 24 (12 M/12 W) •Adolescent	•Trained Average BMI: •M = 22.0±0.5 kg/m^2 •W = 22.4±0.3 kg/m^2	Supra-maximal	30-sec	Cycle ergometry	Random assignment: •Music (M) [tempo: 140 bpm] •No music (NO)	•RPE	•HR	Power Output: •Minimum •Maximum •Mean •Fatigue Index •Fatigue Time	•M = higher post-warm up RPE compared to NO condition for Men (9.6 vs. 8.5) and Women (9.5 vs. 7.8) •M and NO = no difference in maximal HR, mean Power, and Fatigue Index •M = greater overall peak Power (11.1 Watts/kg vs. 10.7 Watts/kg) compared to NO condition
Emery et al. (2003)	•N = 33 (19 M/14 W) •Average age: 62.6±10.5 y	Phase II cardiac rehabilitation patients	85% VO_2max	To exhaustion	Treadmill exercise	Counterbalanced: •Classical music (CM) •No music (NO)	•POMS	•HR •BP	•Cognitive functioning	•No significant differences between music conditions on POMS subscales; •significant main effect for reduction of depressive symptoms •CM = no differences in HR (124.2 bpm vs. 119.7 bpm) or BP (165.3/80.3 vs. 163.3/78.2), and exercise time (21.1 min vs. 21.3 min) compared to NO condition • CM = no difference in depression (0.21 vs. 0.36) or anxiety (1.5 vs. 1.3) subscales of POMS compared to NO condition •CM = increase in cognitive functioning (27.4) compared to NO (26.7) condition
Karageorghis (2000)	•N = 20 •Average age: 21.0±3.0 y	•Healthy •Sport science students	75% HR_{max}	To exhaustion	Cycle ergometry	•Synchronous music (SM) •Asynchronous music (AM) [tempo: 130 bpm each] Control conditions: •Cadence feedback (CF) •Flashing metronome (FM)		•HR	•Endurance time	•SM = higher HR minute before exhaustion compared to CM, FM, and AM •SM = longer time to exhaustion compared to CM, FM •No difference in endurance time between SM and AM
Nelson & Finch (1962)	•N = 16 •College-aged	•Healthy •Physical education students	Maximal	60 sec	Cycle ergometry	Latin Square design: •Fast Music (FM) •Slow Music (SM) •White Noise (WN) •No Sound (NO)			•Total revolutions	•No differences in total revolutions (FM = 264.3 rev; SM = 258.7 rev; WN = 259.7 rev; NO = 258.4) •Many perceived fast music to improve performance
Nelson (1963) Study 1	•N = 16 M •Age range: 19-22 y	Healthy •Physical education students	Maximal	90 sec	Cycle ergometry	Latin Square design: •Fast music (FM) •Slow music (SM) •White noise (WN) •No sound (NO)			•Total revolutions	•No difference between FM (366.35 rev), SM (365.27 rev), WN (366.14 rev), and NO (368.73). •Participants perceived their performance to be better under FM

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Nelson (1963) Study 2	•N = 16 M •Age range: 19-22 y	Healthy •Physical education students	Maximal	90 sec	Cycle ergometry	Latin Square design: •Fast tone (FT) •Slow tone (ST) •Non-rhythmical tone (NRT) •No sound (NO)			•Total revolutions	•No difference between FT (344.75 rev), ST (347.46 rev), NRT (347.21 rev), and NO (347.27 rev)
Nelson (1963) Study 3	•N = 16 M •Age range: 19-22 y	Healthy •Physical education students	Maximal	90 sec	Cycle ergometry	Latin Square design: •Low music intensity (LMI) •Low to High music intensity (LHI) •High music intensity (HMI) •No sound (NO)			•Total revolutions	•No difference between LMI (353.37 rev), LHI (357.56 rev), HMI (456.80 rev), and NO (354.06 rev) •Participants indicated they perceived their performance to be better under higher intensity music
Pujol & Langenfeld (1999)	•N = 15 (12 M / 3 W) •Average age: 24.0±3.4 y	•Trained •Average body fat: 13.1±5.8%	Supra-maximal	To exhaustion	Cycle ergometry	Random order of: •Music [tempo: 120 bpm] •No music			Power Output: •Minimum •Maximum •Mean •Fatigue Index •Fatigue Time	•No difference between Music vs. No Music on any of the performance dependent variables
Schwartz et al. (1990)	•N = 20 (10 M/10 W) Average age: •M = 20.20±1.69 y •W = 21.40±2.17 y	•Untrained Average VO_2max: •M = 44.20±8.91 ml kg min^{-1} •W = 38.75±3.86 ml kg min^{-1}	75% max of GXT	To exhaustion	Treadmill exercise	Randomized order: •Fast music (FM) [tempo: 142-168 bpm] •No music (NO)	•RPE	•HR •RER •VO_2 •V_E •HLa	•Exercise duration	•FM and NO = no difference in relative VO_2, V_E, HR, RER, HLa, and RPE •Both men and women exercise longer in the FM condition compared to the NO condition
Simpson & Karageorghis (2006)	•N = 36 M •Average age: 20.4±1.4 y	•Physically active	Maximal	400-m	Running	Counterbalanced order of: •Synchronous music (SM) •Oudeterous music (OM) [each 135-140 bpm] •White Noise (WH)	•BRUMS		•Running time	•No effect of SM or OM on BRUMS •SM and OM resulted in faster running times compared to WH •No difference between SM and OM on running times •Listening to music accounted for 24% of variance in running times
Szabo et al. (1999)	•N = 24 (12 M/12 W) •Average age: 20.8±0.64 y	•Healthy	Maximal	To exhaustion	Cycle ergometry	Counterbalanced: •No music (NO) •Slow music (SM) •Fast music (FM) •Slow to fast music (SF) •Fast to slow music (FS)	•Subjective preferences	•HR	•Workload	•SF = greater workload (203.13 W) compared to NO (193.7 W), SM (189.6 W), FM (191.7 W), and FS (193.7 W) conditions •NO, SM, FM, SF, and FS = no difference in HR •SF = different "index of efficiency" [final W/final HR] compared to NO, SM, FM, and FS conditions •Most participants preferred the FM and SF conditions
Tenenbaum et al. (2004) Study 1	•N = 15 M •Average age: 23.34 y	•Trained •Average VO_2max: 51.63 ml kg min^{-1}	90% VO_2max	To exhaustion	Treadmill running	Counterbalanced order of: •Rock (RM) •Inspirational (IM) •Dance (DM) •No Music (NO)	•RPE •RDS •Attentional focus	•HR	•Running endurance	•RM, IM, DM, and NO conditions = no effect on RPE and HR •"Mental Toughness" and "Task Completion Thoughts" felt most strongly of all RDS subscales •RM, IM, DM, and NO = no effect on running endurance •IM rated more highly than RM and DM •In general, music had greater effect at beginning compared to end of run •Participants attended more to melody and rhythm compared to lyrics
Tenenbaum et al. (2004) Study 2	• N = 15 M •Average age: 21.65 y	•Trained •Average VO_2max: 50.61 ml kg min^{-1}	90% VO_2max	To exhaustion	Treadmill running	Counterbalanced order of: •Rock (RM) •Inspirational (IM) •Dance (DM) •No Music (NO)	• RPE •RDS •Attentional focus •Exercise thoughts	•HR	•Running endurance	•RM, IM, DM, NO = no effect on RPE or HR •None of the music conditions prevented participants from feeling pain/discomfort at some point in the run (DM: 100%; IM: 74%; RM: 33%, NO: 87%) •IM = greater running time compared to DM and RM conditions •No effect on running endurance between RM, IM, DM compared to NO condition •DM = slower running endurance compared to NO condition •67% of runners perceived NO condition to result in longer run time •>50% of thoughts classified as run-related; attention to music for DM (19%), IM (22%), and RM (5%)

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Thornby et al. (1995)	•N = 36 (11 M/25 W) •Average age: 63.0±8.8 y	•COPD patients •Average FEV1: 48.8±1.0%)	Maximal	To exhaustion	Treadmill exercise	Random order: •Upbeat Music (UM) •Grey Noise (GN) •Silent Tape (ST)	•RPE	•HR	•Exercise Time •External Work	•UM (6.2) and GN (6.5) = lower RPE compared to ST (7.1) condition •UM = higher HR (104 bpm) compared to ST (101 bpm) condition •UM = lower HR when HR plotted against increasing workload •UM = longer exercise time (13.9 min) compared to ST (11.3 min) condition •UM = greater external work (11.8 kcals) compared to GN (8.2 kcals) and ST (7.7 kcals) conditions
Yamamoto et al. (2003)	•N = 6 M •Average age: 24.0±4.1 y	•Physically active •Average BMI: 23.7±0.7 kg m^2	Supra-maximal	45 sec	Cycle ergometry	Counterbalanced: •Fast music (FM) •Slow Music (SM) [music prior to exercise]		•HLa •Ammonia •Epi •Norepi •Dopa •HR	•Watts	•FM and SM = no difference in HR (176 bpm vs. 174 bpm), HLa (11.7 mmol/l vs. 13.5 mmol/l) and ammonia (198.4 µmol/l vs. 180.4 µmol/l), Epi (895.6 pg/ml vs. 1237.2 pg/ml), Norepi (3896.0 pg/ml vs. 5117.8pg/ml), and Dopa (35.1 pg/ml vs. 43.8 pg/ml concentrations •FM and SM = no difference in power output

Physiological Abbreviations: HR = Heart Rate; HRV = Heart Rate Variability; VO_2 = Oxygen Consumption; V_E = Minute Ventilation; BP = Blood Pressure; RPP = Rate Pressure Product; RR = Respiratory Rate; RER = Respiratory Exchange Ratio; RQ = Respiratory Quotient; METS = Metabolic Equivalents; HLa = Blood Lactate; SpO2 = Saturated Oxygen; FEV1 = Forced Expired Ventilation in 1 sec; Epi = Epinephrine; Norepi = Norepinephrine; Dopa = Dopamine

Psychological Abbreviations: FS = Feeling Scale; RPE = Ratings of Perceived Exertion; AD-ACL = Activation-Deactivation Adjective Checklist; PANAS = Postive Affect/Negative Affect Scale; PACES = Physical Activity Enjoyment Scale; IMI = Intrinsic Motivation Inventory; EIS = Exercise Identity Scale; STAI = State-Trait Anxiety Inventory; POMS = Profile of Mood States; BRUMS = Brunel Mood Scale; CES-D = Center for Epidemiological Studies Depression Scale; HRQoL = Health-related Quality of Life; GQoL = Global Quality of Life; LSI = Life Satisfaction Inventory; BMRI = Brunel Music Rating Inventory; RDS = Running Discomfort Scale; VAS-I/U = Visual Analog Scale-Intensity/Unpleasantness; MMSE = Mini-Mental State Examination; ADS-6 = Amsterdam Dementia Screening Test 6; BOP = Stockton Geriatric Rating Scale; PAQ = Physical Activity Questionnaire

APPENDIX G: VISUAL-ONLY STIMULI TABLE

Table IIIa. Investigations of visual-only stimuli grouped based on exercise intensity levels characterized as submaximal.

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Plante, Aldridge, et al. (2003)	•N = 88 (44 M / 44 F) •Average age: 38.10±12.31 y	Healthy	60%-70% HR_{max}	30-min	Cycle ergometry	Randomly assigned to: •Virtual reality alone (VR) •Virtual reality + exercise (VR-E) •Exercise alone (EX) •Control (Con)	•AD-ACL •RPE	•HR		•VR-E and EX = greater Energy scores •Females = higher Energy values between conditions compared to males •VR-E = lower Tiredness scores compared to VR and EX condiions •VR = more Tension compared to EX and VR-E conditions •VR-E and EX conditions = greater Relaxation scores •Females more Relaxed post-exercise than males •VR-E = higher RPE compared to EX condition
Plante, Aldridge, Su, et al. (2003)	•N = 154 (52 M / 102 F) •College-aged	Healthy	Submaximal ($3.0\ m{\cdot}hr^{-1}$)	20-min	Treadmill or outdoor walking	Randomly assigned to: •Outdoor walk (Out) •Virtual reality + treadmill walk (VR-TM) •Virtual reality alone (VR) •Control (Con)	•AD-ACL			•Out = males significantly decreased Tiredness; females significantly increased Energy, less Tiredness, less Calmness •Females = significantly less Tiredness in VR-TM and Con conditions; significantly less Tension in Con condition; significantly less Energy in VR condition •Energy: significantly increased for males and females in Out, VR-TM, and Con conditions •Tiredness: significantly increased for males in Out and Con conditions compared to VR condition; significantly increased for females in Out condition compared to Con; significantly decreased for females in Out condition and males in VR-TM condition compared to VR condition •Tension = significantly increased for females only in the VR-TM condition compared to Con condition •Calmness = significant increase in VR compared to Out, VR-TM, and Out conditions for females only
Plante, Cage, et al. (2006)	•N = 112 (47 M / 65 F) •College-aged	Healthy	Submaximal ($4.8\ km{\cdot}hr^{-1}$)	20-min	Treadmill or outdoor walking	Randomly assigned to: •Outdoor walk (Out) •Virtual reality + treadmill walk (VR-TM) •Virtual reality alone (VR)	•AD-ACL •PACES			•Out rated as more enjoyable cmpared to VR condition •Energy: significantly increased in Out condition compared to VR condition •Tiredness: significantly increased for females in experimental conditions compared to males after controlling for enjoyment; Out condition produced least and VR condition produced most tired reports; females reported increased tired scores following VR condition •Tension: significantly lower scores in VR-TM condition •Calmness: Out produced significantly less calm scores
Plante, Frazier, et al. (2003)	•N = 121 (49 M / 72 F) •Average age: 18.58±1.12 y	Healthy	60%-70% HR_{max}	30-min	Cycle ergometry	Randomly assigned to: •Virtual reality alone (VR) •Virtual reality + exercise (VR-E) •Exercise alone (EX) •Control (Con)	•AD-ACL •RPE	•HR		•VR, VR-E, EX = greater Energy and Calmness and less Tiredness and Tension post-exercise than Con •Increased HR during VR-E and EX compared to VR and Con •No difference in HR between VR-E and EX •Females = greater Energy and less Tiredness than males •Males = more Calmness and less Tension compared to females immediately post-exercise •RPE not reported
Robergs et al. (1998) Study 1	•N = 12 (8 M / 4 W) •Average age: 27.9±6.5 y	Healthy	70% VO_2max	35-min	Cycle ergometry	Conditions of: •Cycling video (CV) •Blank video (BV) •No video (NO)	•RPE •FS	•HR •VO_2		•No difference in RPE, HR, VO_2 •Affective ratings higher during CV at mins 15, 25, & 35 compared to BV and higher at mins 25 & 35 compared to NO condition

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Russell & Newton (2008)	•N = 168 (78 M / 90 W) •Average age: 21.51±5.31 y	•Healthy •BMI range: 24.69 to 28.83 kg/m^2	60% to 70% HR_{max}	30-min	Cycle ergometry	Conditions of: •Interactive video game cycle ergometry (VGCE) •Cycle ergometry (CE) •Video game (VG)	•RPE •PANAS			•VG produced significantly higher negative affect immediately and 10-min post-session compared to VGCE and CE conditions •VGCE and CE conditions produced significantly higher positive affect 10-min post-exercise compared to VG condition •No difference in RPE between VGCE and CE conditions
Russell & Weeks (1994)	•N = 7 M •Age range: 18 - 23 y	•Trained •Competitive cyclists	75% HR_{max}	60-min	Cycle ergometry	Conditions randomized: •Monitor HR (HR) •Video (V) [count word "duck"] •Control (Con)	•RPE	•HR		•HR, V, and Con = no difference in HR •V = higher RPE compared to HR and Con conditions •4 cyclists claimed HR condition ride easier; 3 said Con condition ride easier
Russell et al. (2003)	•N = 53 (32 M / 21 W) •College-aged	•Regularly active	60%-75% HRR	25-min	Cycle ergometry	Randomly assigned to: •Television viewing (TV) •Reading (R) •Control (Con)	•POMS •RPE			•TMD improved from pre to post-exercise within-conditions, not between-conditions •RPE increased over time within-conditions, not between-conditions
Stones (1980)	•N = 8 M •Average age: 25 yrs	•Healthy •Recreational runners •<15 m·wk^{-1}	•Optimal pace •10% slower •10% faster	Track lap time between 100 - 129 sec	Running	Counterbalanced order: •With ski goggles (visual input attenuation) •Without ski goggles	Perceived: •Pace •Time to complete distance •Fatigue		•Run time	Wearing ski goggles: •Higher perceived pace •Lower perceived time to complete distance •Less perceived fatigue •Slower lap times

Table IIIb. Investigations of visual-only stimuli grouped based on exercise intensity levels characterized as self-selected.

Annesi & Mazas (1997)	•N = 39 •UB group: n = 14 [3 M / 11 W]; Average age: 41.9±12.8 y •RB group: n = 13 [5 M / 8 W]; Average age: 34.6±1.9 y •VR group: n = 12 [3 M / 9 W]; Average age: 36.2±6.7 y	•Sedentary (no physical activity in previous 2 y)	•Self-selected	•3 d·wk^{-1} •14 wk	Cycle ergometry	Random assignment to: •Upright (UB) •Recumbent (RB) cycle ergometry (both non-virtual-reality) •Virtual-reality recumbent bicycle ergometer (VRB)	•EFI •SMI		•Attendance •Adherence	•Dropout rate: 13/39 •Adherence higher with VR (83.3%) compared to RB (61.5%) and UB (57.1%) groups •VRB associated with greater attendance compared to RB •Virtual reality equipment associated with greater attendance compared to non-virtual reality equipment •SMI not associated with increased attendance •Greater PE, Revital, Tranq, and lower Phy Exh with RB and VRB •UB resulted in lower Tranq and higher Phy Exh

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Hull & Potteiger (1999)	•N = 10 W •Average age: 33.8±5.5 y	•Trained •Average VO_2max: 52.7±6.0 $ml\cdot kg\cdot min^{-1}$	Self-paced to produce: •Prescribed RPE •HLa of 2.5 $mmol\cdot L^{-1}$	30-min	Treadmill running	Counterbalanced conditions: •High-action video (HA) •Low-action video (LA) •Control		•HR •VO_2 •HLa	•Running speed	•No difference in HR, VO_2, HLa, or treadmill speed
Robergs et al. (1998) Study 2	•N = 12 (7 M / 5 W) •Average age: 24.8±4.9 y	Healthy	•Self-selected	35-min	Cycle ergometry	Conditions of: •Cycling video (CV) •No video (NO)	•RPE •FS	•HR •VO_2 •HLa	•Watts	•Cycled at higher workloads at all time points during CV condition •Higher HR from min 10 to min 30 under CV condition •Mean VO_2 higher during CV condition •RPE higher at mins 5, 15, & 25 under CV condition •No difference in HLa or affect across conditions

Physiological Abbreviations: HR = Heart Rate; VO_2 = Oxygen Consumption; HLa = Blood Lactate

Psychological Abbreviations: FS = Feeling Scale; EFI = Exercise-induced Feeling Inventory; SEES = Subjective Exercise Experience Scale; AD-ACL = Activation-Deactivation Adjective Checklist; RPE = Ratings of Perceived Exertion; POMS = Profile of Mood States; SMI = Self-Motivation Inventory

APPENDIX H: AUDIO-VISUAL STIMULI TABLE

Table Ia. Investigations of audio-visual stimuli at exercise intensities characterized as self-selected (n = 1) or submaximal (n = 6).

Study/Participant Characteristics			**Exercise Stimulus**				**Dependent Variables**			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
MacRae et al. (2003)	•N = 10 W Average age: •Trained: 39.05±2.6 y •Untrained: 19.85±1.5 y	Average VO_2max: •Trained (n = 5): 46.4±4.7 ml·kg·min^{-1} •Untrained (n = 5): 34.5±5.7 ml·kg·min^{-1}	•Self-selected	30-min	Cycle ergometry	Counterbalanced order: •Video feedback + music (VFM) •Music-alone (M) [•Self-selected music]	•RPE •SEES •EFI •POMS •Satisfaction Scale	•HR •VO_2	•Cycling speed •Distance	•No difference in central or peripheral RPE, SEES, EFI, or Satisfaction Scale conditions •M = greater feelings of Composure and Energy compared to VFM condition across groups Self-selected intensities: •Trained = 80.4 %VO_2max (VFM); 81.4 %VO2max (M) •Untrained = 65.0 %VO_2max (VFM); 60.4 %VO_2max (M) •Speed = between-group differences with condition (ES = 0.62) •Distance = between-group differences with condition (ES = 0.57) [Untrained cycled faster and further in VFM compared to M]
Abadie et al. (1996)	•N = 30 M •Age range: 18-25 y	•Healthy	•Sub-maximal •122.5 W	6-min	Cycle ergometry	Counterbalanced conditions: •Music video (MV) •Quiet condition (QC)	•RPE			•MV and QC = no difference in RPE (MV = 13.5 vs. QC = 13.3)
Annesi (2001)	•N = 50 (18 M / 32 W) •Average age: 32.0±8.3 y	•Sedentary (no physical activity last 2 y)	•Sub-maximal •"Moderate or higher"	•3 d·wk^{-1} •14-wk	Aerobic exercise	Random assignment to: •Music(M) •Television (T) •Combined entertainment (CE) •Control	•Adherence •AFQ •SMI	•Estimated VO_2max	•Length of sessions	•CE group = significant increase in estimated VO_2max (8.0 ml·kg·min^{-1}) compared to M, T, and C •No significant differences in adherence across groups •CE group (33%) showed significantly lower dropout than M (64%), C (64%, T (67%) •CE group completed significantly longer exercise sessions compared to T and C groups •SMI and AFQ subscales of Association and Distress did not differ across conditions •CE group reported greater focus on television than audio options
Nethery (2002)	• N = 13 M •Average age: 22.2±0.8 y	•Untrained •Average VO_2max: 46.9±3.0 ml·kg·min^{-1}	•50% •80% VO_2peak	15-min	Cycle ergometry	Latin-square assignment to: •Music (M) •Video (V) •Sensory Deprivation (SD) •Control (Con)	•RPE	•HR		•M = significantly lower RPE in 50% and 80% VO_2max exercise intensities compared to all other conditions •SD = significantly higher RPE was found in both exercise intensities •No difference in HR within exercise intensity condition across all groups
Nethery et al. (1991)	•N = 12 (8 M / 4 W) Average age: •M = 21.2± 1.2 y •W = 21.5±1.0 y	•Untrained •Healthy •Average est. VO_2max: M = 46.0±2.9 ml·kg·min^{-1} W = 45.8±5.5	•75% estimated HR_{max}	20-min	Cycle ergometry	Latin-square assignment to: •Music (M) [self-selected] •Video (V) •Sensory Deprivation (SD) •Control (Con)	•RPE			•Overall mean RPE significantly different in all conditions except V vs. Con conditions •M = lower RPE at min 5 compared to Con and SD conditions and at mins 10 & 15 compared to SD, Con, and V conditions •V = lower RPE compared to SD at min 15 •SD = higher RPE at min 20 compared to all other conditions

Study/Participant Characteristics			Exercise Stimulus				Dependent Variables			
Reference	**Sample**	**Fitness Status**	**Intensity**	**Duration**	**Mode**	**Conditions**	**Psych**	**Physio**	**Perform**	**Results**
Scott et al. (1999)	•N = 9 (5 M / 4 W) •Average age: 20.23±1.88 y	•Trained •Competitive rowers	•Women: Level 2 resistance •Men: Level 3 resistance	40-min	Rowing	•Rowing audiotape (RA) •Music (M) •Rowing videotape (RV)			•Distance rowed	•RA: 3.77% increase •RV: 1.27% increase •M: 0.77% increase
White & Potteiger (1996)	•N = 24 (13 M / 11 W) Average age: •M = 22.6±3.1 y •W = 20.6±1.6 y	•Physically active Average VO_2peak: •M = 42.5±4.9 $ml \cdot kg \cdot min^{-1}$ •W = 34.4±5.3 $ml \cdot kg \cdot min^{-1}$	•70% VO_2peak	20-min	Cycle ergometry	Counterbalanced: •Upbeat music (UM) [tempo: 140-145 bpm] •Stunt video (SV) [no sound] •Music/Video (MV) •Sensory Deprivation (SD)	RPE: •Overall •Peripheral •Central	•HR		•Average HR = no difference between UM (168.7 bpm), SV (167.7 bpm), MV (166.0 bpm), and SD (169.5 bpm) conditions •VM = higher peripheral RPE (13.2) at min 5 compared to UM (12.2) and MV (12.3) conditions •SV = higher peripheral RPE (17.2) at min 20 compared to MV (16.3) condition •SV = higher central RPE compared to MV condition at mins 5 (12.3 vs. 10.8), 10 (13.9 vs. 12.7), 15 (15.2 vs. 13.9), and 20 (16.3 vs. 14.9) •SV = higher central RPE compared to UM condition at mins 5 (12.3 vs. 11.0), 10 (13.9 vs. 12.9), and 20 (16.3 vs. 15.2) •SV = higher central RPE (12.3) at min 5 compared to SD (11.3) condition •SV = higher overall RPE compared to MV at mins 5 (12.7 vs. 11.6), 10 (14.5 vs. 13.5), 15 (15.8 vs. 14..8), and 20 (16.7 vs. 15.6) •SV = higher overall RPE compared to UM condition at mins 5 (12.7 vs. 11.8) and 10 (14.5 vs. 13.6)

Physiological Abbreviations: HR = Heart Rate; VO_2 = Oxygen Consumption; HLa = Blood Lactate

Psychological Abbreviations: FS = Feeling Scale; EFI = Exercise-induced Feeling Inventory; SEES = Subjective Exercise Experience Scale; AD-ACL = Activation-Deactivation Adjective Checklist; RPE = Ratings of Perceived Exertion; POMS = Profile of Mood States; SMI = Self-Motivation Inventory

APPENDIX I: ABSOLUTE HEART RATE TABLE

Table 3. Heart rate (beats/min) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	96.86±10.61	96.29±7.78	99.14±9.69
Min 1	98.29±11.66	97.64±8.14	99.54±9.13
Min 2	104.25±12.85	103.68±8.14	104.21±8.75
VT-1	121.93±13.70	122.96±14.39	123.75±13.12
VT	128.50±13.73	130.04±13.90	132.29±12.96
VT+1	137.36±14.57	138.82±14.20	141.00±13.10
VT+2	144.32±14.92	146.46±14.71	148.14±13.86
End-1	173.39±9.41	173.82±10.99	175.96±10.88
End	179.04±10.20	180.21±10.95	181.82±9.77

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) starting at Min 1 through End.

APPENDIX J: PERCENTAGE OF MAXIMAL HEART RATE TABLE

Table 4. Heart rate (expressed as a percentage of maximal heart rate) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	54.19±5.91%	53.60±5.19%	54.66±5.97%
Min 1	55.00±6.59%	54.36±5.35%	54.91±5.96%
Min 2	58.34±7.23%	57.69±5.15%	57.49±5.82%
VT-1	68.18±7.43%	68.25±6.98%	68.10±6.56%
VT	71.86±7.40%	72.24±7.22%	72.82±6.71%
VT+1	76.78±7.56%	77.13±7.44%	77.66±7.27%
VT+2	80.67±7.77%	81.39±7.91%	81.59±7.59%
End-1	96.89±2.21%	96.46±2.10%	96.78±2.90%
End	100.00±0.00%	100.00±0.00%	100.00±0.00%

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) starting at Min 1 through End.

APPENDIX K: ABSOLUTE OXYGEN CONSUMPTION ($L \cdot MIN^{-1}$) TABLE

Table 5. Oxygen consumption (Liters/min) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	0.83±0.17	0.81±0.14	0.85±0.19
Min 1	0.84±0.15	0.83±0.14	0.87±0.19
Min 2	0.94±0.17	0.89±0.15	0.95±0.18
VT-1	1.39±0.49	1.41±0.44	1.46±0.48
VT	1.68±0.51	1.67±0.47	1.73±0.51
VT+1	1.73±0.51	1.77±0.45	1.81±0.51
VT+2	1.90±0.51	1.94±0.48	1.97±0.53
End-1	2.66±0.72	2.70±0.80	2.77±0.80
End	2.83±0.70	2.89±0.79	2.94±0.82

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) starting at Min 1 through End.

APPENDIX L: RELATIVE OXYGEN CONSUMPTION ($ml \cdot kg \cdot min^{-1}$) TABLE

Table 6. Oxygen consumption (ml·kg·min^{-1}) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	12.08±2.39	11.73±1.89	12.21±2.57
Min 1	12.21±1.94	12.05±1.82	12.63±2.37
Min 2	13.62±2.30	12.97±2.01	13.70±2.29
VT-1	19.73±5.38	20.11±4.52	20.73±5.07
VT	23.63±5.86	23.40±5.10	24.28±5.77
VT+1	24.86±5.54	25.37±4.68	25.83±5.14
VT+2	27.19±5.50	27.75±4.86	28.24±5.32
End-1	37.94±7.35	38.44±8.15	39.52±7.96
End	40.39±6.80	41.16±7.90	42.00±8.02

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) starting at Min 1 through End.

APPENDIX M: PERCENTAGE OF PEAK OXYGEN CONSUMPTION TABLE

Table 7. Oxygen consumption (expressed as a percentage of peak oxygen consumption) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	30.33±6.24%	29.30±6.36%	29.91±6.99
Min 1	30.76±5.67%	30.08±6.24%	30.70±6.70
Min 2	34.24±6.24%	32.35±6.71%	33.43±7.34
VT-1	48.78±9.54%	49.10±7.02%	49.36±8.25
VT	56.75±9.68%	55.62±7.47%	55.49±8.19
VT+1	61.81±10.32%	62.22±7.91%	61.91±8.59
VT+2	67.85±11.27%	68.13±8.40%	67.82±9.42
End-1	93.60±3.75%	93.14±3.93%	93.96±3.95
End	100.00±0.00%	100.00±0.00%	100.00±0.00%

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) starting at Min 1 through End.

APPENDIX N: PEAK POWER OUTPUT (WATTS) TABLE

Table 8. Power output (expressed in Watts) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	30.00±0.00	30.00±0.00	30.00±0.00
Min 1	41.55±0.63	41.21±2.06	41.31±1.36
Min 2	56.93±1.03	56.34±2.02	56.48±1.09
VT-1	101.00±37.72	106.24±36.70	107.41±37.32
VT	116.14±35.96	121.28±36.61	122.55±37.30
VT+1	131.03±35.88	136.24±36.62	137.48±37.26
VT+2	145.76±35.86	151.79±36.16	152.48±37.22
End-1	207.03±51.92	210.38±56.38	211.72±55.07
End	220.90±51.62	224.55±56.39	226.17±54.91

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.001$) for all time points.

APPENDIX O: ATTENTIONAL FOCUS TABLE

Table 9. Attentional focus for each experimental conditions across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Min 2	6.35±2.04†	4.96±2.15#	8.07±1.41‡
Pre-VT	5.79±2.17†	4.14±2.05#	7.11±1.62‡
VT	4.93±2.34†	3.32±1.76#	6.66±1.91‡
Post-VT	3.89±1.93	3.25±1.40#	6.14±2.05‡
End	2.72±2.22	2.50±1.71#	3.89±2.51

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.05$) starting at Min 2 through End. Significant differences between conditions ($p \leq 0.05$) are indicated as follows: † = Sensory Deprivation and Biofeedback; ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

APPENDIX P: RATING OF PERCEIVED EXERTION TABLE

Table 10. Ratings of perceived exertion for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Warm Up	8.38±1.50	8.45±1.55	8.00±1.36
Min 1	8.76±1.64	8.83±1.65	8.52±1.57
Min 2	9.59±1.90	9.55±1.70	9.17±1.61
VT-1	12.34±2.14	12.21±1.99	11.83±1.65
VT	13.55±1.84	13.10±1.86	12.76±1.66
VT+1	14.34±1.80	13.83±1.79	13.48±1.50‡
VT+2	15.03±1.78	14.72±1.87	14.28±1.49
End-1	18.17±1.56	17.86±1.36	17.62±1.66‡
End	18.72±1.44	18.52±1.27	18.41±1.55

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.05$) starting at Warm Up through End. ‡Significant differences between Sensory Deprivation and Music-Television conditions ($p \leq 0.05$).

APPENDIX Q: AFFECTIVE VALENCE TABLE

Table 11. Ratings of affective valence (+5 to -5) for each experimental conditions across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Post-Mask	2.58±1.21	2.72±1.16	2.52±1.38
Min 1	2.48±1.21	2.83±1.10	3.03±1.05‡
Min 2	2.38±1.15	2.69±1.04#	2.93±1.03‡
VT-1	1.69±1.51	2.03±1.32#	2.62±0.98‡
VT	1.45±1.48	1.66±1.34#	2.31±1.23‡
VT+1	1.03±1.59	1.52±1.50#	2.34±1.56‡
VT+2	0.79±1.72	1.21±1.54#	1.97±1.66‡
End-1	-0.45±2.28	-0.38±1.93#	0.34±2.13‡
End	-0.90±2.43	-1.03±2.28#	0.03±2.38‡

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music; # = Biofeedback and Music.

APPENDIX R: PERCEIVED ACTIVATION TABLE

Table 12. Perceived activation (1 to 6) for each experimental condition across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	Sensory Deprivation	Biofeedback	Music
Post-Mask	2.97±0.91	3.21±1.08	3.10±1.01
Min 1	3.12±0.96	3.45±1.15	3.66±1.17‡
Min 2	3.12±0.92	3.53±1.15	3.78±1.03‡
VT-1	3.78±1.10	3.91±1.07	4.07±0.75
VT	4.05±1.27	4.03±1.18	4.17±0.97
VT+1	4.17±1.28	4.03±1.21	4.12±0.86
VT+2	4.29±1.21	4.03±1.35	4.28±1.03
End-1	4.69±1.47	4.52±1.55	4.62±1.21
End	4.97±1.30	4.62±1.54	4.72±1.36

All values are means±SD (N = 29). Significant time main effect and condition by time interaction ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: ‡ = Sensory Deprivation and Music.

APPENDIX S: POST-EXERCISE AFFECTIVE VALENCE TABLE

Table 13. Ratings of affective valence immediately post-exercise (PE), following a cool down period (PCD), and every 10 min of a 30-min recovery period (P10, P20, P30).

	Sensory Deprivation	Biofeedback	Music
PE	-0.55±2.56‡	-0.55±2.64	0.24±2.34
PCD	1.52±1.94‡	1.93±1.93	2.41±1.68
P10	2.69±1.54	2.45±1.30#	3.03±1.24
P20	3.24±1.15	3.03±1.09	2.83±1.31
P30	3.59±1.05	3.41±1.09	3.38±1.12

All values are means±SD (N = 29). Significant time main effect and condition by time interaction ($p \leq 0.05$). Significant differences between conditions ($p \leq 0.05$) are indicated as follows: **‡** = Sensory Deprivation and Music; **#** = Biofeedback and Music.

APPENDIX T: POST-EXERCISE PERCEIVED ACTIVATION

Table 14. Perceived activation immediately post-exercise (PE), following a cool down period (PCD), and every 10 min of a 30-min recovery period (P10, P20, P30).

	Sensory Deprivation	Biofeedback	Music
PE	4.97±1.32	4.69±1.58	4.83±1.39
PCD	4.10±1.21	3.90±1.26	4.21±1.18
P10	3.36±1.39	3.21±1.26	3.38±1.42
P20	2.83±1.28	2.83±1.23	2.83±1.36
P30	2.59±1.35	2.48±1.12	2.66±1.34

All values are means±SD (N = 29). Significant time main effect ($p \leq 0.05$).

APPENDIX U: EFFECT SIZES FOR AFFECTIVE VALENCE TABLE

Table 15. Effect sizes for ratings of affective valence (+5 to -5) between experimental conditions (Sensory Deprivation [SD], Biofeedback [BF], Music-Television [MTV]) across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	SD vs. BF	SD vs. MTV	BF vs. MTV
Post-Mask	.1165	.0456	.1548
Min 1	.2986	.4790*	.1835
Min 2	.2789	.4970*	.2288
VT-1	.2365	.7208**	.5007*
VT	.1468	.6235**	.4986*
VT+1	.3128	.8884***	.5286*
VT+2	.2538	.6887**	.4683*
End-1	.0327	.3533	.3495
End	.0544	.3815	.4487*

Statistical significance is indicated as follows: *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.

APPENDIX V: EFFECT SIZES FOR PERCEIVED ACTIVATION TABLE

Table 16. Effect sizes for ratings of perceived activation (1 to 6) between experimental conditions (Sensory Deprivation [SD], Biofeedback [BF], Music-Television [MTV]) across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	SD vs. BF	SD vs. MTV	BF vs. MTV
Post-Mask	.2371	.1334	.1038
Min 1	.3073	.4978*	.1786
Min 2	.3884	.6668*	.2259
VT-1	.1182	.3039	.1708
VT	.0161	.1119	.1279
VT+1	.1109	.0450	.0846
VT+2	.2001	.0088	.2045
End-1	.1110	.0513	.0710
End	.2423	.1854	.0679

Statistical significance is indicated as follows: *$p \leq 0.05$.

APPENDIX W: EFFECT SIZES FOR ATTENTIONAL FOCUS

Table 17. Effect sizes for attentional focus between experimental conditions (Sensory Deprivation [SD], Biofeedback [BF], Music-Television [MTV]) at Min 2 of the exercise bout, pre- (Pre-VT), at the moment of (VT), and post-ventilatory threshold (Post-VT), and at the end of the exercise bout.

	SD vs. BF	SD vs. MTV	BF vs. MTV
Min 2	.6540**	.9672***	1.6868***
Pre-VT	.7708**	.6797**	1.5851***
VT	.7668**	.7987**	1.7933***
Post-VT	.3743	1.1144***	1.6234***
End	.1095	.4869*	.6382**

Statistical significance is indicated as follows: * $p \leq 0.05$, ** $p \leq 0.01$, ***$p \leq 0.001$.

APPENDIX X: EFFECT SIZES FOR RATINGS OF PERCEIVED EXERTION TABLE

Table 18. Effect sizes for ratings of perceived exertion between experimental conditions (Sensory Deprivation [SD], Biofeedback [BF], Music-Television [MTV]) across selected time points of an incremental cycling ergometry test to volitional exhaustion.

	SD vs. BF	SD vs. MTV	BF vs. MTV
Warm Up	.0453	.2619	.3045
Min 1	.0420	.1475	.1899
Min 2	.0219	.2353	.2264
VT-1	.0621	.2633	.2051
VT	.2400	.4448*	.1903
VT+1	.2803	.5121*	.2091
VT+2	.1675	.4508*	.2567
End-1	.2090	.3369	.1560
End	.1453	.2044	.0766

Statistical significance is indicated as follows: *$p \leq 0.05$.

APPENDIX Y: EFFECT SIZES FOR POST-EXERCISE AFFECTIVE VALENCE TABLE

Table 19. Effect sizes for ratings of pleasure-displeasure between experimental conditions immediately post-exercise (PE), following a cool down period (PCD), and every 10 min of a 30-min recovery period (P10, P20, P30).

	SD vs. BF	SD vs. MTV	BF vs. MTV
PE	.0000	.3178	.3124
PCD	.2090	.4839*	.2617
P10	.1661	.2399	.4504*
P20	.1849	.3282	.1637
P30	.1659	.1908	.0268

Statistical significance is indicated as follows: *$p \leq .05$.

APPENDIX Z: EFFECT SIZES FOR POST-EXERCISE PERCEIVED ACTIVATION TABLE

Table 20. Effect sizes for perceived activation between experimental conditions immediately post-exercise (PE), following a cool down period (PCD), and every 10 min of a 30-min recovery period (P10, P20, P30).

	SD vs. BF	SD vs. MTV	BF vs. MTV
PE	.1897	.1019	.0928
PCD	.1597	.0908	.2505
P10	.1116	.0140	.1249
P20	.0000	.0000	.0000
P30	.0875	.0513	.1438

APPENDIX AA: POWER OUTPUT GRAPH

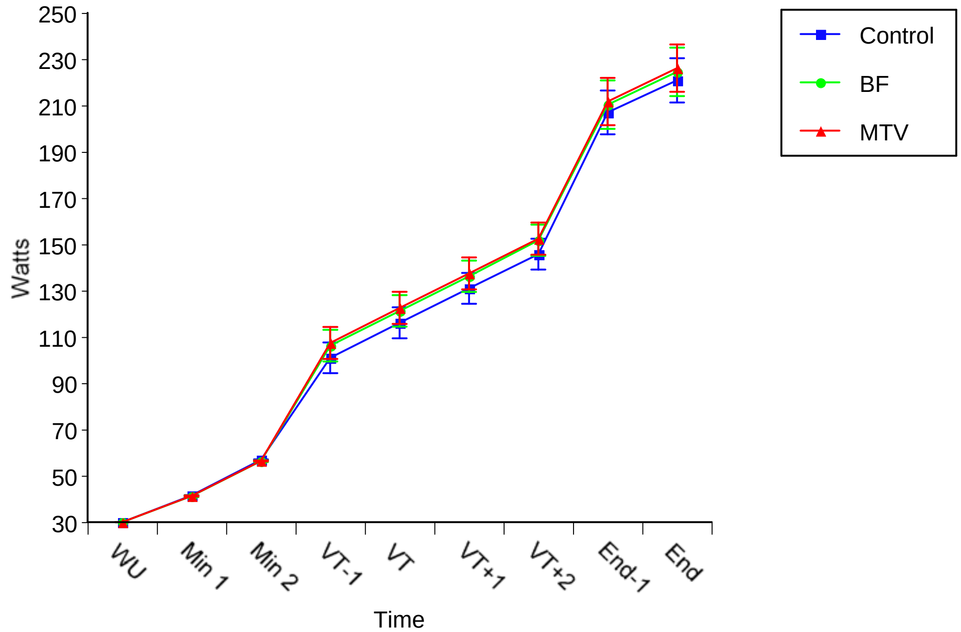


Figure 9. Line graph of power output across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time effect ($p \leq 0.05$).

APPENDIX BB: PEAK HEART RATE, POWER OUTPUT, AND OXYGEN CONSUMPTION ($L \cdot min^{-1}$) GRAPHS

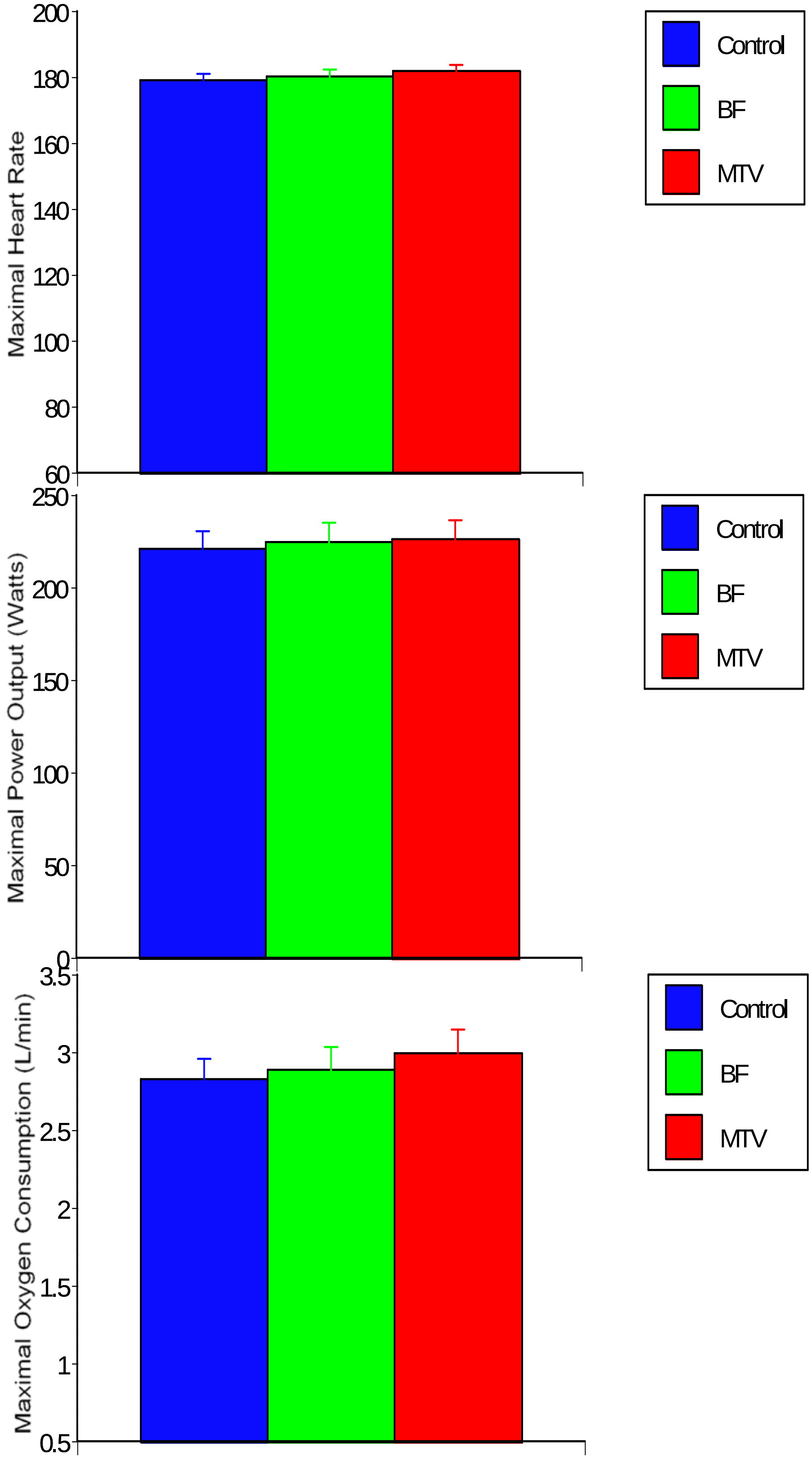


Figure 10a-c. Maximal heart rate, power output, and oxygen consumption across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television.

APPENDIX CC: POST-EXERCISE PERCEIVED ACTIVATION GRAPH

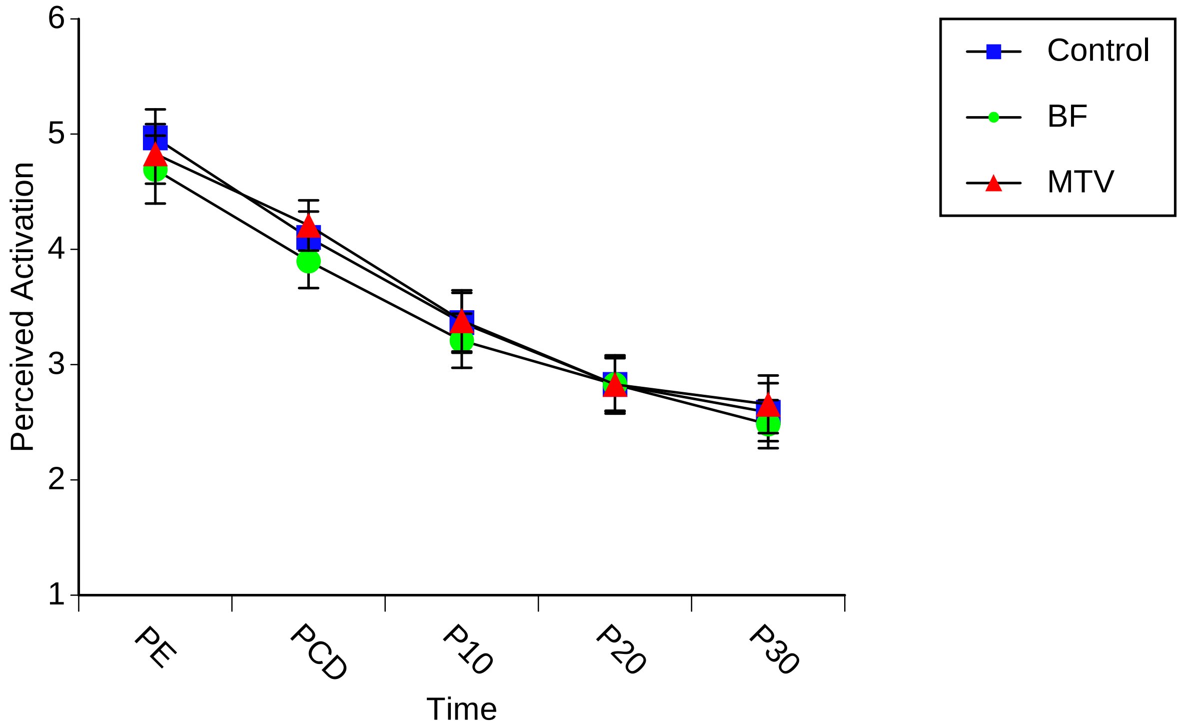


Figure 11. Line graph of post-exercise perceived activation across experimental conditions of Sensory Deprivation (control), Biofeedback (heart rate and respiration), and Music-Television during an incremental bout of cycling exercise to volitional exhaustion. Significant time main effect ($p \leq 0.05$).

REFERENCES

1. Abadie, B.R., Chance, M.K., O'Nan, D., & Lay, C. (1996). Viewing music videotapes during exercise and ratings of perceived exertion. *Perceptual and Motor Skills*, *83*, 226.

2. Abraham, A., & Thomas, C.S. (1999). The effects of music tempo on self-selected exercise intensity in active female college students. *Medicine and Science in Sport and Exercise*, *31* (5), S315 [abstract].

3. Annesi, J.J. (2001). Effects of music, television, and a combination of entertainment system on distraction, exercise adherence, and physical output in adults. *Canadian Journal of Behavioural Sciences*, *33* (3), 193-201.

4. Annesi, J.J. (2003). Effects of a cognitive behavioral treatment package on exercise attendance and drop out in fitness centers. *European Journal of Sport Sciences*, *3* (2), 1-16.

5. Annesi, J.J., & Mazas, J. (1997). Effects of virtual reality-enhanced exercise equipment on adherence and exercise-induced feeling states. *Perceptual and Motor Skills*, *85*, 835-844.

6. Anshel, M.H., & Marisi, D.Q. (1978). Effect of music and rhythm on physical performance. *Research Quarterly*, *49*, 377-381.

7. Atkinson, G., Wilson, D., & Eubank, M. (2004). Effects of music on work-rate distribution during a cycling time trial. *International Journal of Sports Medicine*, *25*, 611-615.

8. Baden, D.A., McLean, T.L., Tucker, R., Noakes, T.D., & St. Clair Gibson, A. (2005). Effect of anticipation during unknown or unexpected exercise duration on rating of perceived exertion, affect, and physiological function. *British Journal of Sports Medicine*, *39*, 742-746.

9. Baden, D.A., Warwick-Evans, L., & Lakomy, J. (2004). Am I nearly there? The effect of anticipated running distance on perceived exertion and attentional focus. *Journal of Sport and Exercise Psychology*, *26*, 215-231.

10. Bartholomew, J.B., & Miller, B.M. (2002). Affective responses to an aerobic dance class: the impact of perceived performance. *Research Quarterly for Exercise and Sport*, *73* (3), 301-309.

11. Bauldoff, G.S., Hoffman, L.A., Zullo, T.G., & Sciurba, F.C. (2002). Exercise maintenance following pulmonary rehabilitation. Effect of distractive stimuli. *Chest*, *122* (3), 948-954.

12. Beaudoin, C.M., Crews, D.J., & Morgan, D.W. (1998). Influence of psychogenic factors during a prolonged maximal run. *Journal of Sport Behavior*, *21*, 377-381.

13. Beaver, D.P. (1976). Pace through music. *Modern Athlete and Coach*, *14*, 12-13.

14. Becker, N., Brett, S., Chambliss, C., Crowers, K., Haring, P., Marsh, C., & Montemayor, R. (1994). Mellow and frenetic antecedent music during athletic performance of children, adults, and seniors. *Perceptual and Motor Skills*, *79*, 1043-1046.

15. Becker, N., Chambliss, C., Marsh, C., & Montemayor, R. (1995). Effects of mellow and frenetic music and stimulating and relaxing scents on walking by seniors. *Perceptual and Motor Skills*, *80*, 411-415.

16. Beckett, A. (1990). The effects of music on exercise as determined by physiological recovery heart rates and distance. *Journal of Music Therapy*, *27* (3), 126-136.

17. Bernardi, L., Porta, C., & Sleight, P. (2006). Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. *Heart*, *92*, 445-452.

18. Bharani, A., Sahu, A., & Mathew, V. (2004). Effect of passive distraction on treadmill exercise test performance in healthy males using music. *International Journal of Cardiology*, *97*, 305-306.

19. Blanchard, C.M., Rodgers, W.M., & Gauvin, L. (2004). The influence of exercise duration and cognitions during running on feeling states in an indoor running track environment. *Psychology of Sport and Exercise*, *5*, 119-133.

20. Blumenstein, B. (1992). Music…before starting. *Fitness and Sports Review International*, *27*, 49-50.

21. Boutcher, S.H., & Trenske, M. (1990). The effects of sensory deprivation and music on perceived exertion and affect during exercise. *Journal of Sport and Exercise Psychology*, *12*, 167-176.

22. Brewer, B.W., Van Raalte, J.L., & Linder, D.E. (1996). Attentional focus and endurance performance. *The Applied Research in Coaching and Athletic Annual*, *11*, 1-14.

23. Brown, P. (1980). The use of music in a fitness program. *CAHPER Journal*, *46* (5), 39-43.

24. Brownley, K.A., McMurray, R.G., & Hackney, A.C. (1995). Effects of music on physiological and affective responses to graded treadmill exercise in trained and untrained runners. *International Journal of Psychophysiology*, *19*, 193-201.

25. Chipman, L. (1967). The effects of selected music on endurance. *Completed Research in Health, Physical Education, and Recreation*, *9*, 111 [abstract].

26. Chlan, L. (1998). Effectiveness of a music therapy intervention on relaxation and anxiety for patients receiving ventilatory assistance. *Heart Lung*, *27* (3), 169-176.

27. Ciccomascolo, L.E., Finn, J.A., Barbarich, J.E., & Rinehardt, K.F. (1995). Effect of up-beat music on endurance performance. *Medicine and Science in Sport and Exercise*, *27* (5), S151 [abstract].

28. Cioffi, D. (1991). Sensory awareness versus sensory impression: affect and attention interact to produce somatic meaning. *Cognition and Emotion*, *5*, 275-294.

29. Cohen, S.L., Paradis, C., & LeMura, L.M. (2007). The effects of contingent-monetary reinforcement and music on exercise in college students. *Journal of Sport Behavior*, *30* (2), 146-160.

30. Connolly, C.T., & Janelle, C.M. (2003). Attentional strategies in rowing: performance, perceived exertion, and gender considerations. *Journal of Applied Sport Psychology*, *15*, 195-212.

31. Copeland, B.L., & Franks, B.D. (1991). Effects of types and intensities of background music on treadmill endurance. *Journal of Sports Medicine and Physical Fitness*, *31*, 100-103.

32. Côté, J., Salmela, J., & Papathanasopoulu, K.P. (1992). Effects of progressive exercise on attentional focus. *Perceptual and Motor Skills*, *75*, 351-354.

33. Coutts, C.A. (1961). Effects of music on pulse rates and work output of short duration. *Research Quarterly*, *36*, 17-21.

34. Couture, R.T., Jerome, W., & Tihanyi, J. (1999). Can associative and dissociative strategies affect the swimming performance of recreational swimmers? *Sport Psychologist*, *13*, 334-343.

35. Couture, R.T., Singh, M., Lee, W., Chahal, P., Wankel, L., Oseen, M., & Wheeler, G. (1994). The effect of mental training on the performance of military endurance tasks in the Canadian infantry. *International Journal of Sports Psychology*, *25* (1), 144-157.

36. Couture, R.T., Tihanyi, J., & St. Aubin, M. (2003). Can performance in a distance swim be improved by increasing a preferred cognitive thinking strategy? *The Sport Journal*, *6*.

37. Crust, L. (2004). Effects of familiar and unfamiliar asynchronous music on treadmill walking endurance. *Perceptual and Motor Skills*, *99*, 361-368.

38. Crust, L., & Clough, P.J. (2006). The influence of rhythm and personality in the endurance response to motivational asynchronous music. *Journal of Sports Sciences*, *24*, 187-195.

39. Crust, L., Clough, P.J., & Robertson, C. (2004). Influence of music and distraction on visual search performance of participants with high and low affect intensity. *Perceptual and Motor Skills*, *98*, 888-896.

40. Cullari, S., & Semanchick, O. (1989). Music preferences and perceptions of loudness. *Perceptual and Motor Skills*, *68*, 186.

41. De Bourdeaudhuij, I., Crombez, G., Deforche, B., Vinaimont, F., Debode, P., & Bouckaert, J. (2002). Effects of distraction on treadmill running time in severely obese children and adolescents. *International Journal of Obesity*, *26*, 1023-1029.

42. Deligniéres, D., & Brisswalter, J. (1994). Influence of an added perceptual motor task on perceived exertion: A test of the dissociation effect. *Perceptual and Motor Skills*, *78*, 855-858.

43. Dorfman, L. Ya. (1986). The effect of emotions evoked by music on physical performance depending on the strength of the nervous system. *Soviet Journal of Psychology*, *7* (5), 827-832.

44. Durtschi, S.K., & Weiss, M.R. (1984). Psychological characteristics of elite and nonelite marathon runners. In D.M. Landers (ed.) *The 1984 Olympic Scientific Congress proceedings*, *Vol. 3*, *Sport and elite performers* (pp. 73-80). Champaign, IL: Human Kinetics.

45. Edworthy, J., & Waring, H. (2006). The effects of music tempo and loudness level on treadmill exercise. *Ergonomics*, *49* (15), 1597-1610.

46. Ekkekakis, P., & Petruzzello, S.J. (1999). Acute aerobic exercise and affect: current status, problems and prospects regarding dose-response. *Sports Medicine*, *28* (5), 337-374.

47. Elliott, D., Carr, S., & Orme, D. (2005). The effect of motivational music on sub-maximal exercise. *European Journal of Sport Science*, *5* (2), 97-106.

48. Elliott, D., Carr, S., & Savage, D. (2004). Effects of motivational music on work output and affective responses during sub-maximal cycling of a standardized perceived identity. *Journal of Sport Behavior*, *27* (2), 134-147.

49. Emery, C.F., Hsiao, E.T., Hill, S.M., & Frid, D.J. (2003). Short-term effects of exercise and music on cognitive performance among participants in a cardiac rehabilitation program. *Heart and Lung*, *32* (6), 368-373.

50. Fatouros, I., Chatzinikolaou, A., Jamurtas, A., Kallistratos, I., Baltzi, M., Douroudos, I., Fotinakis, P., Taxildaris, K., Vezyraki, P., & Evangelou, A. (2005). The effects of self-selected music on physiological responses and performance during cardiovascular exercise. *Medicine and Science in Sport and Exercise*, *37* (5), S106 [abstract].

51. Ferguson, A.R., Carbonneau, M.R., & Chambliss, C. (1994). Effects of positive and negative music on performance of a karate drill. *Perceptual and Motor Skills*, *78*, 1217-1218.

52. Fillingim, R.B., & Fine, M.A. (1986). The effects of internal versus external information processing on symptom perception in an exercise setting. *Health Psychology*, *5*, 115-123.

53. Fillingim, R.B., Roth, D.L., & Haley, W.E. (1989). The effects of distraction on the perception of exercise-induced symptoms. *Journal of Psychosomatic Research*, *33*, 241-248.

54. Franks, B.D., & Myers, B.C. (1984). Effects of talking on exercise tolerance. *Research Quarterly in Exercise and Sports*, *55*, 237-241.

55. Gallagher, P.M. (1996). No effect of music on performance and physiological parameters during a simulated race. *Medicine and Science in Sport and Exercise*, *28* (5), S158 [abstract].

56. Gauvin, L., & Rejeski, W.L. (1993). The exercise-induced feeling inventory: development and initial validation. *Journal of Sport and Exercise Psychology*, *15*, 403-423.

57. Gfeller, K. (1988). Musical components and styles preferred by young adults for aerobic fitness activities. *Journal of Music Therapy*, *25*, 28-43.

58. Goff, K.L., Potteiger, J.A., & Schroeder, J.M. (1996). A comparison of different types of music on ratings of perceived exertion and heart rate during moderate intensity exercise. *Medicine and Science in Sport and Exercise*, *28* (5), S57.

59. Golzález-Alonso, J., Dalsgaard, M.K., Osada, T., Volianitis, S., Dawson, E.A., Yoshiga, C.C., & Secher, N.H. (2004). Brain and central hemodynamics and oxygentation during maximal exercise inhumans. *Journal of Physiology*, *557*, 331-342.

60. Hagen, B., Armstrong-Esther, C., & Sandilands, M. (2003). On a happier note: validation of musical exercise for older persons in long-term care settings. *International Journal of Nursing Studies*, *40*, 347-357.

61. Hardy, C.J., & Rejeski, W.L. (1989). Not what, but how one feels: the measurement of affect during exercise. *Journal of Sport and Exercise Psychology*, *11*, 304-317.

62. Harte, J.L., & Eifert, G.H. (1995). The effects of running, environment, and attentional focus on athlete's catecholamine and cortisol levels and mood. *Psychophysiology*, *32*, 49-54.

63. Hatfield, B.D., Spalding, T.W., Mahon, A.D., Brody, E.B., & Vaccaro, P. (1986). Ventilatory economy as a function of attentional self-focus during treadmill running. *Psychophysiology*, *23*, 440-441. [abstract]

64. Hatfield, B.D., Spalding, T.W., Mahon, A.D., Slater, B.A., Brody, E.B., & Vaccaro, P. (1992). The effect of psychological strategies upon cardiorespiratory and muscular activity during treadmill running. *Medicine and Science in Sports and Exercise*, *24* (2), 218-225.

65. Hassmèn, P., & Koivula, N. (1996). Ratings of perceived exertion by women with internal or external locus of control. *Journal of General Psychology*, *123*, 297-307.

66. Hayakawa, Y., Miki, H., Takada, K., & Tanaka, K. (2000). Effects of music on mood during bench stepping exercise. *Perceptual and Motor Skills*, *90*, 307-314.

67. Hohler, V. (1989). Sport and music. *Sport Science Review*, *12*, 41-44.

68. Höhne, E. (1979). The place of music in physical culture and sport. *Journal of Sports Medicine and Physical Fitness*, *19*, 97.

69. Hull, G.R., & Potteiger, J.A. (1999). Regulation of exercise intensity using ratings of perceived exertion during passive visual distraction. *Perceptual and Motor Skills*, *89*, 684-694.

70. Jensen, S.M., Cram, H.D., & Van Duser, B.L. (2000). Effect of music tempo on heart rate and perceived exertion during rest, exercise, and recovery. *Research Quarterly for Exercise and Sport*, *71* (1), A29.

71. Jette, A.M., Lachman, M., Giorgetti, M.M., Assmann, S.F., Harris, B.A., Levenson, C., Wernick, M., & Krebs, D. (1999). Exercise – It's never too late: The Strong-for-Life Program. *American Journal of Public Health*, *89* (1), 66-72.

72. Johnson, G., Otto, D., & Clair, A.A. (2001). The effect of instrumental and vocal music on adherence to a physical rehabilitation exercise program with persons who are elderly. *Journal of Music Therapy*, *35* (2), 82-96.

73. Johnson, J.H., & Siegal, D.S. (1992). Active vs. passive attentional manipulation and multidimensional perceptions of exercise intensity. *Canadian Journal of Sports Science*, *12*, 41-45.

74. Karageorghis, C. (2000). Effects of synchronous and asynchronous music in cycle ergometry. *Journal of Sports Sciences*, *18* (1), 16.

75. Karageorghis, C.I. (1999). Music in sport and exercise: theory and practice. *The Sport Journal*, *2* (2), 1-5.

76. Karageorghis, C.I., & Deeth, I.P. (2002). Effects of motivational and oudeterous asynchronous music on perceptions of flow. *Journal of Sports Sciences*, *20*, 66-67.

77. Karageorghis, C.I., Jones, L., & Low, D.C. (2006). Relationship between exercise heart rate and music tempo preference. *Research Quarterly for Exercise and Sport*, *77* (2), 240-250.

78. Karageorghis, C., Jones, L., & Stuart, D.P. (*in press*). Psychological effects of music tempi during exercise. *International Journal of Sports Medicine.*

79. Karageorghis, C.I., & Terry, P.C. (1997). The psychophysical effects of music in sport and exercise: a review. *Journal of Sport Behavior*, *20* (1), 54-68.

80. Karageorghis, C.I., Terry, P.C., & Lane, A.W. (1999). Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: the Brunel Music Rating Inventory. *Journal of Sports Sciences*, *17*, 713-724.

81. Kendzierski, D., & DiCarlo, K.J. (1991). Physical Activity Enjoyment Scale: two validation studies. *Journal of Sport and Exercise Psychology*, *13*, 50-64.

82. Kim, S.J., & Koh, I. (2005). The effects of music on pain perception of stroke patients during upper extremity joint exercises. *Journal of Music Therapy*, *42* (1), 81-92.

83. Kirby, R.J. (1996). Ultraendurance running: a case study. *International Journal of Sport Psychology*, *27*, 109-116.

84. Kirby, A.M., & Murphy, R.J.L. (2003). Does music alter performance and change perception of effort during exercise? *Medicine and Science in Sport and Exercise*, *35* (5), S286 [abstract].

85. Koivula, N., & Hassmèn, P. (1998). Central, local, and overall ratings of perceived exertion during cycling and running by women with an external or internal locus of control. *Journal of General Psychology*, *125*, 17-29.

86. Krishnamurti, S., & Grandjean, P.W. (2003). Effects of simultaneous exercise and loud music on hearing acuity and auditory function. *Journal of Strength and Conditioning Research*, *17* (2), 307-313.

87. LaCaille, R.A., Masters, K.S., & Heath, E.M. (2004). Effects of cognitive strategy and exercise setting on running performance, perceived exertion, affect, and satisfaction. *Psychology of Sport and Exercise*, *5*, 461-476.

88. Lancioni, G.E., O'Reilly, M.F., Singh, N.N., Oliva, D., Piazzolla, G., & Groeneweg, J. (2004). Assessing influence of stimulation on mood and aberrant behavior of persons with multiple disabilities during brief treadmill sessions. *Perceptual and Motor Skills*, *99*, 931-936.

89. Lancioni, G.E., Singh, N.N., O'Reilly, M.F., Oliva, D., Campodonico, F., & Groeneweg, J. (2003). Assessing the effects of automatically delivered stimulation on the use of simple exercise tools by students with multiple disabilities. *Research in Developmental Disabilities*, *24*, 475-483.

90. Lancioni, G.E., Singh, N.N., O'Reilly, M.F., Oliva, D., Campodonico, F., & Groeneweg, J. (2004). Use of simple exercise tools by students with multiple disabilities: impact of automatically delivered stimulation on activity level and mood. *Journal of Developmental and Physical Disabilities*, *16* (2), 171-178.

91. Leslie, J.J. (1968). The effect of music on the development of speed in running. *Completed Research in Health, Physical Education, and Recreation*, *10*, 129 [abstract].

92. Loucks, L.E. (2000). Use of music as a distracter during submaximal exercise. *Missouri Journal of Health, Physical Education, Recreation, and Dance*, *10*, 38-43.

93. MacEneaney, O.J., O'Gorman, D., Moran, K., Kerrane, J., Woods, C., McCaffrey, N., McArdle, S., & Moyna, N.M. (2004). Effect of preferred music on perception of effort and self-selected exercise intensity. *Medicine and Science in Sport and Exercise*, *36* (5), S126 [abstract].

94. MacIntyre, P.D., Bloomer, C., Provan, D., & Sturrock, R. (2001). The effect of music on exercise capacity in patients with rheumatoid arthritis. *Medicine and Science in Sport and Exercise*, *33* (5), S322 [abstract].

95. MacNay, S.K. (1995). The influence of the preferred music on the perceived exertion, mood, and time estimation scores of patients participating in a cardiac rehabilitation exercise program. *Music Therapy Perspectives*, *13*, 91-96.

96. Macone, D., Baldari, C., Zelli, A., & Guidetti, L. (2006). Music and physical activity in psychological well-being. *Perceptual and Motor Skills*, *103* (1), 285-295.

97. Marin-Hernandez, J., & Aragón-Vargas, L.F. (1999). Effect of sound intensity of music on perceived exertion during cycle exercise. *Medicine and Science in Sport and Exercise*, *31* (5), S314 [abstract].

98. Martin, G.L., Vause, T., & Schwartzman, L. (2005). Experimental studies of psychological interventions with athletes in competitions. Why so few? *Behavior Modification*, *29* (4), 616-641.

99. Martin, J.E., Dubbert, P.M., Katell, A.D., Thompson, J.K., Raczynski, J.R., Lake, M., et al. (1984). Behavioral control of exercise in sedentary adults: Studies 1 through 6. *Journal of Consulting and Clinical Psychology*, *52* (5), 795-811.

100. Masters, K.S. (1992). Hypnotic susceptibility, cognitive dissociation, and runner's high in a sample of marathon runners. *American Journal of Clinical Hypnosis*, *34*, 193-201.

101. Matesic, B.C., & Cromartie, F. (2002). Effects music has on lap pace, heart rate, and perceived exertion during a 20-minute self-paced run. *The Sport Journal*, *5* (1), 1-8.

102. Mathews, R.M., Clair, A.A., & Kosloski, K. (2001). Keeping the beat: use of rhythmic music during exercise activities for the elderly with dementia. *American Journal of Alzheimer's Disease and Other Dementias*, *16* (6), 377-380.

103. McKinney, C.H., Tims, F.C., Kumar, A.M., & Kumar, M. (1997). The effect of selected classical music and spontaneous imagery on plasma β-endorphins. *Journal of Behavioral Medicine*, *20* (1), 85-99.

104. Miller, A., & Donohue, B. (2003). The development and controlled evaluation of athletic mental preparation strategies in high school distance runners. *Journal of Applied Sport Psychology*, *15*, 321-334.

105. Morgan, W.P., Horstman, D.H., Cymerman, A., & Stokes, J. (1983). Facilitation of physical performance by means of cognitive strategy. *Cognitive Therapy and Research*, *7*, 251-264.

106. Murrock, C.J. (2002). The effects of music on the rate of perceived exertion and general mood among coronary artery bypass graft patients enrolled in cardiac rehabilitation phase II. *Rehabilitation Nursing*, *27*, 227-231.

107. Nelson, D.O. (1963). Effect of selected rhythms and sound intensity on human performance as measured by the bicycle ergometer. *Research Quarterly*, *34* (4), 484-488.

108. Nelson, D.O., & Finch, L.W. (1962). Effect of audio-analgesia on gross motor performance involving acute fatigue. *Research Quarterly*, *33* (4), 588-592.

109. Nethery, V.M. (2002). Competition between internal and external sources of information during exercise: Influence on RPE and the impact of the exercise load. *Journal of Sports Medicine and Physical Fitness*, *42*, 172-178.

110. Nethery, V.M., Harmer, P.A., & Taaffe, D.R. (1991). Sensory mediation of perceived exertion during submaximal exercise. *Journal of Human Movement Studies*, *20*, 201-211.

111. Nielsen, H.B., Boesen, M., & Secher, N.H. (2001). Near-infrared spectroscopy determined brain and muscle oxygenation during exercise with normal and resistive breathing. *Acta Physiologica Scandinavia*, *171*, 63-70.

112. Nielsen, H.B., Boushel, R., Madsen, P., & Secher, N.H. (1999). Cerebral desaturation during exercise reversed by O2 supplementation. *American Journal of Physiology*, *277*, H1045-H1052.

113. North, A.C., & Hargreaves, D.J. (1996). Responses to music in aerobic exercise and yogic relaxation classes. *British Journal of Psychology*, *87*, 535-547.

114. North, A.C., & Hargreaves, D.J. (2000). Musical preferences during and after relaxation and exercise. *American Journal of Psychology*, *113* (1), 43-67.

115. Otto, D., Cochran, V., Johnson, G., & Clair, A.A. (1999). The influence of background music on task engagement in frail, older persons in residential care. *Journal of Music Therapy*, *36* (3), 182-195.

116. Padgett, V.R., & Hill, A.K. (1989). Maximizing athletic performance in endurance events: a comparison of cognitive strategies. *Journal of Applied Social Psychology*, *19*, 331-340.

117. Pates, J., Karageorghis, C.I., Fryer, R., & Maynard, I. (2003). Effects of asynchronous music on flow states and shooting performance among netball players. *Psychology of Sport and Exercise*, *4*, 415-427.

118. Pennebaker, J.W., & Lightner, J.M. (1980). Competition of internal and external information in an exercise setting. *Journal of Personality and Social Psychology*, *39*, 165-174.

119. Pennebaker, J.W., & Skelton, J.A. (1978). Psychological parameters of physical symptoms. *Personality and Social Psychology Bulletin*, *4*, 524-530.

120. Pfister, T., Berrol, C., & Caplan, C. (1998). Effects of music on exercise and perceived symptoms in patients with chronic obstructive pulmonary disease. *Journal of Cardiopulmonary Rehabilitation*, *18* (3), 228-232.

121. Plante, T.G., Aldridge, A., Bogden, R., & Hanelin, C. (2003). Might virtual reality promote the mood benefits of exercise? *Computers in Human Behavior*, *19*, 495-509.

122. Plante, T.G., Aldridge, A., Su, D., Bogdan, R., Belo, M., & Kahn, K. (2003). Does virtual reality enhance the management of stress when paired with exercise? An exploratory study. *International Journal of Stress Management*, *10* (3), 203-216.

123. Planted, T.G., Cage, C., Clements, S., & Stover, A. (2006). Psychological benefits of exercise paired with virtual reality: Outdoor exercise energizes whereas indoor virtual reality relaxes. *International Journal of Stress Management*, *13* (1), 108-117.

124. Plante, T.G., Frazier, S., Tittle, A., Babula, M., Ferlic, E., & Riggs, E. (*in press*). Does virtual reality enhance the psychological benefits of exercise?

125. Potteiger, J.A., Schroeder, J.M., & Goff, K.L. (2000). Influence of music on ratings of perceived exertion during 20 minutes of moderate intensity exercise. *Perceptual and Motor Skills*, *91*, 848-854.

126. Priest, D.L., Karageorghis, C.I., & Sharp, N.C.C. (2004). The characteristics and effects of motivational music in exercise settings: the possible influence of gender, age, frequency of attendance, and time of attendance. *Journal of Sports Medicine and Physical Fitness*, *44* (1), 77-86.

127. Pujol, T.J., & Langenfeld, M.E. (1999). Influence of music on Wingate anaerobic test performance. *Perceptual and Motor Skills*, *88* (1), 292-296.

128. Pujol, T.J., Langenfeld, M.E., Pujol, K.J., Wilken, B.J., & Huskey, J.A. (1999). Effects of music on ratings of perceived exertion and lactate. *Medicine and Science in Sport and Exercise*, *31* (5), S214 [abstract].

129. Pujol, T.J., Pujol, K.J., & Creamer, D.R. (1996). Impact of music on rating of perceived exertion during leg ergometry. *Medicine and Science in Sport and Exercise*, *28* (5), S71 [abstract].

130. Pujol, T.J., Wagganer, J.D., Langenfeld, M.E., Sutherlin, A.E., Tucker, J.E., Leible, M.A., Barnes, J.T., & Jones, E.J. (2003). Music has no effect on the RPE-lactate relationship. *Medicine and Science in Sport and Exercise*, *35* (5), S286 [abstract].

131. Rejeski, W.J. (1981). The perception of exertion: a social psychophysiological integration. *Journal of Sport Psychology*, *4*, 305-320.

132. Rejeski, W.J. (1985). Perceived exertion: An active or passive process? *Journal of Sport Psychology*, *7*, 371-378.

133. Robergs, R.A., Bereket, S., & Knight, M.A. (1998). Video-assisted cycling alters perception of effort and increases self-selected exercise intensity. *Perceptual and Motor Skills*, *86*, 915-927.

134. Roberts, J.W. Jr., Ritenhour, M., & Goss, F. (2004). Impact of music on RPE during submaximal treadmill exercise. *Medicine and Science in Sport and Exercise*, *36* (5), S125 [abstract].

135. Rushall, B.S., Hall, M., Roux, L., Sasseville, J., & Rushall, A.C. (1988). Effects of three types of thought content instructions on skiing performance. *The Sport Psychologist*, *2*, 283-297.

136. Russell, W.D., & Newton, M. (2008). Short-term psychological effects of interactive video game technology exercise on mood and attention. *Educational Technology & Society*, *11* (2), 294-308.

137. Russell, W.D., & Weeks, D.L. (1994). Attentional style in ratings of perceived exertion during physical exercise. *Perceptual and Motor Skills*, *78*, 779-783.

138. Sacks, M.H., Milvy, P., Perry, S.W., & Sherman, L.R. (1981). Mental status and psychological coping during a 100-mile race. In M.H. Sacks & M.L. Sachs (Eds.), *Psychology of Running* (pp. 166-175). Champaign, IL: Human Kinetics.

139. Salmela, J.H., & Ndoye, O.D. (1986). Cognitive distortions during progressive exercise. *Perceptual and Motor Skills*, *63*, 1067-1072.

140. Schomer, H.H. (1986). Mental strategies and the perception of effort of marathon runners. *International Journal of Sport Psychology*, *17*, 41-59.

141. Schomer, H.H. (1987a). The relationship between cognitive strategies and perceived effort of marathon runners. *South African Journal of Research in Sport, Physical Education, and Recreation*, *10 (1)*, 37-64.

142. Schomer, H.H. (1987b). Mental strategy training programme for marathon runners. *International Journal of Sport Psychology*, *18*, 133-151.

143. Schomer, H.H. (1990). A cognitive strategy training programme for marathon runners: ten case studies. *South African Journal of Research in Sport, Physical Education, and Recreation*, *134* (2), 47-78.

144. Schomer, H.H., & Connolly, M.J. (2002). Cognitive strategies used by marathoners in each quartile of a training run. *South African Journal of Research in Sport, Physical Education, and Recreation*, *24*, 87-99.

145. Schwartz, S.E., Fernhall, B., & Plowman, S.A. (1990). Effects of music on exercise performance. *Journal of Cardiopulmonary Rehabilitation*, *10*, 312-316.

146. Seath, L., & Thow, M. (1995). The effect of music on perception of effort and mood during aerobic type exercise. *Physiotherapy*, *81*, 592-596.

147. Sentelik, M. (1967). The relative effectiveness of two methods of exercise for first grade boys. *Completed Research in Health, Physical Education, and Recreation*, *9*, 112 [abstract].

148. Siegal, D., Johnson, J., & Davis, C. (1981). Attention and perception of intensity of work. *Perceptual and Motor Skills*, *53*, 331-337.

149. Simes, W.E. (1982). A new look at association/dissociation in long distance runners. *Running Psychology*, *4*, 1-3.

150. Simpson, S.D., & Karageorghis, C.I. (2006). The effects of synchronous music on 400-m sprint performance. *Journal of Sports Sciences*, *24* (10), 1095-1102.

151. Smith, J.C., & Widmer, R.J. (2004). The effect of different types of music on performance of exhaustive cycling exercise. *Medicine and Science in Sport and Exercise*, *36* (5), S166 [abstract].

152. Snyder, E.E. (1993). Responses to musical selections and sport: an auditory elicitation approach. *Sociology of Sport Journal*, *10*, 168-182.

153. Sorenson, L., Czech, D.R., Klein, J., & Lachowetz, T. (2008). Listen Up! The experience of music in sport – a phenomenological investigation. *Athletic Insight*, *10* (2).

154. Stamford, B.A., Weltman, A., & Foulke, E. (1979). Information processing and perceived effort during bicycle ergometer work. *Medicine and Science in Sport*, *11*, 78 [abstract].

155. Stanley, C.T., Pargman, D., & Tenenbaum, G. (2007). The effect of attentional coping strategies on perceived exertion in a cycling task. *Journal of Applied Sport Psychology*, *19*, 352-363.

156. Steptoe, A., & Cox, S. (1988). Acute effects of aerobic exercise on mood. *Health Psychology*, *7* (4), 329-340.

157. Stetson, B.A., Frommelt, S.J., Boutelle, K.N., & Cole, J. (1995). Exercise-related thoughts in cardiac exercise programs: A study of exercise-adherent cardiac rehabilitation patients. *International Journal of Rehabilitation and Health*, *1* (2), 1995.

158. Stevens, M., & Lane, A. (2000). Mood-regulating strategies used by athletes. *Journal of Sports Sciences*, *18* (1), 58.

159. Stevens, M.J., & Lane, A.M. (2001). Mood-regulating strategies used by athletes. *Athletic Insight*, *3* (3).

160. Stones, M.J. (1980). Running under conditions of visual input attenuation. *International Journal of Sport Psychology*, *11*, 172-179.

161. Szabo, A., & Griffiths, I. (2003). Evaluation of the motivational quality of music played during exercise at two fitness centers using the Brunel Music Rating Inventory. *Journal of Sports Sciences*, *21*, 360.

162. Szabo, A., Small, A., & Leigh, M. (1999). The effects of slow- and fast-rhythm classical music on progressive cycling to voluntary physical exhaustion. *Journal of Sports Medicine and Physical Fitness*, *39*, 220-225.

163. Szmedra, L., & Bacharach, D.W. (1998). Effect of music on perceived exertion, plasma lactate, norepinephrine and cardiovascular hemodynamics during treadmill running. *International Journal of Sports Medicine*, *19*, 32-37.

164. Tammen, V.V. (1996). Elite middle and long distance runner's associative/dissociative coping. *Journal of Applied Sport Psychology*, *8*, 1-8.

165. Tenenbaum, G. (2005). The study of perceived and sustained effort: concepts, research findings, and new directions. In *Handbook of Research in Applied Sport and Exercise Psychology: International Perspectives* (D. Hackfort, JL Duda, & R. Lidor, eds). Fitness Information Technology: Morgantown, WV Pp. 335-349.

166. Tenenbaum, G., & Connolly, C.T. (2008). Attention allocation under varied workload and effort perception in rowers. *Psychology of Sport and Exercise*, *9*, 704-717.

167. Tenenbaum, G., Lidor, R., Lavyan, N., Morrow, K., Tonnel, S., Gershgoren, A., & Johnson, M. (2004). The effect of music type on running perseverance and coping with effort sensations. *Psychology of Sport and Exercise*, *5*, 89-109.

168. Thornby, M.A., Haas, F., & Axen, K. (1995). Effect of distractive auditory stimuli on exercise tolerance in patients with COPD. *Chest*, *107*, 1213-1217.

169. Uppal, A.K., & Datta, U. (1990). Cardio-respiratory response of junior high school girls to exercise performance with and without music. *Journal of Physical Education and Sport Sciences*, *2*, 52-56.

170. Urakawa, K., & Yokoyama, K. (2005). Music can enhance exercise-induced sympathetic dominancy assessed by heart rate variability. *Tohoku Journal of Experimental Medicine*, *206*, 213-218.

171. Weinberg, R.S., Smith, J., Jackson, A., & Gould, D. (1984). Effect of association, dissociation and positive self-talk strategies on endurance performance. *Canadian Journal of Applied Sport Sciences*, *9*, 25-32.

172. Welch, A.S., Hulley, A., Ferguson, C., & Beauchamp, M.R. (2007). Affective responses of inactive women to a maximal incremental exercise test: A test of the dual-mode model. *Psychology of Sport and Exercise*, *8*, 401-423.

173. Welsh, M.C., Labbé, E.E., & Delaney, D. (1991). Cognitive strategies and personality variables in adherence to exercise. *Psychological Reports*, *68*, 1327-1335.

174. Wininger, S.R., & Pargman, D. (2003). Assessment of factors associated with exercise enjoyment. *Journal of Music Therapy*, *40* (1), 57-73.

175. Wrisberg, C.A., Franks, B.D., Birdwell, M.W., & High, D.M. (1988). Physiological and psychological responses to exercise with an induced attentional focus. *Perceptual and Motor Skills*, *66*, 603-616.

176. Yamamoto, T., Ohkuwa, T., Itoh, H., Kitoh, M., Terasawa, J., Tsuda, T., Kitagawa, S., & Sato, Y. (2003). Effects of pre-exercise listening to slow and fast rhythm music on supramaximal cycle performance and selected metabolic variables. *Archives of Physiology and Biochemistry*, *111* (3), 211-214.

177. Yamashita, S., Iwai, K., Akimoto, T., Sugawara, J., & Kono, I. (2006). Effects of music during exercise on RPE, heart rate, and the autonomic nervous system. *Journal of Sports Medicine and Physical Fitness*, *46* (3), 425-430.

VITA

NAME OF AUTHOR: Erik Lind

DATE AND PLACE OF BIRTH: December 27, 1968, South Bend, IN

DEGREES AWARDED:

B.A. in Psychology/Sociology, Baylor University, 1991
M.S. in Kinesiology, Indiana University, 1995
M.S. in Counseling/Counselor Education, Indiana University 1998
Ph.D. in Kinesiology, Iowa State University, 2008

HONORS AND AWARDS:

Pease Family Doctoral Research Grant Recipient, Spring 2008
College of Human Sciences Graduate Student Scholarship, Spring 2008

PROFESSIONAL EXPERIENCE:

Graduate Assistant, Department of Kinesiology, Iowa State University, 2002-2008
Assistant Professor, Department of Physical Education, SUNY-College at Oneonta, 2008 to present

PROFESSIONAL PUBLICATIONS:

Ekkekakis, P., Lind, E., Hall, E.E., & Petruzzello, S.J. (2008). Do regression-based computerized algorithms for determining the ventilatory threshold agree? *Journal of Sports Sciences*, *26* (9), 967-976.

Lind, E., Ekkekakis, P., & Vazou, S. (2008). The affective impact of exercise intensity that slightly exceeds the preferred level: “Pain” for no additional “gain”. *Journal of Health Psychology*, *13* (4), 458-462.

Ekkekakis, P., Backhouse, S.H., Gray, C., & Lind, E. (2008). Walking is popular among adults but it is pleasant? A framework for clarifying the link between walking and affect as illustrated in two studies. *Psychology of Sport and Exercise*, *9* (3), 246-264.

Ekkekakis, P., Lind, E., Hall, E.E., & Petruzzello, S.J. (2007). Can self-reported tolerance of exercise intensity play a role in exercise testing? *Medicine and Science in Sport and Exercise*, *39* (7), 1193-1199.

Ekkekakis, P., & Lind, E. (2006). Exercise does not feel the same when you are overweight: The impact of self-selected and imposed exercise intensity on exertion and affect. *International Journal of Obesity*, *30* (4), 652-660.

Ekkekakis, P., Lind, E., & Joens-Matre, R.R. (2006). Can self-reported preference for exercise intensity predict physiologically defined self-selected exercise intensity? *Research Quarterly for Exercise and Sport*, *77*, 81-90.

Lind, E., Joens-Matre, R.R., & Ekkekakis, P. (2005). What intensity of physical activity do formerly sedentary middle-aged women select? Evidence of a coherent pattern from physiological, perceptual, and affective markers. *Preventive Medicine*, *40*, 407-419.

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my thanks to those who helped me with various aspects of conducting research and the writing of this thesis. First and foremost, Dr. Panteleimon Ekkekakis for his guidance, support, and patience throughout this research and my graduate studies at Iowa State University. I would also like to thank my committee members for their efforts and contributions to this work and my professional preparation: Dr. Rick L. Sharp, Dr. Greg Welk, Dr. Mack C. Shelley, and Dr. Doug A. Gentile. I would like to thank all of those individuals involved in the data collection process. There are too many to name without the fear of forgetting someone. You know who you are and thank you for your assistance. I would like to thank Gary and Janet McOmber for your support in helping me realize this endeavor. I would like to thank my parents, George and Barbara Lind, for instilling in me the belief that this could be achieved.

A special thank you is reserved for the Pease family. Thank you for your continued sponsorship of the programs our graduate students and faculty in the Department of Kinesiology at Iowa State University have available. Because of your generosity, students like me get to experience the things graduate students in other programs do not and are allowed to carry out the research of our dreams.

Finally, I would like to thank my wife, Kathy, for your patience, resolve and love, and my son, Austin, for giving me a sense of urgency that only you could. Kathy and Austin -- I dedicate this to you.